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A retirement planning model using Monte Carlo simulation.

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THESIS

A RETIREMENT PLANNING MODEL USING MONTE CARLO SIMULATION

by

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December 2000

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A RETIREMENT PLANNING MODEL USING MONTE CARLO SIMULATION

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ABSTRACT

Uncertainty exists in retirement planning. The purpose of this thesis was to develop a stochastic retirement planning model to aid military personnel and decision/policy makers in evaluating retirement planning issues from a probabilistic perspective. The stochastic model developed differs from the ubiquitous retirement planning calculators available from many financial institutions and at many finance-related websites in that it accounts for the effects of uncertainty surrounding inflation and investment rates of return during one's investing "lifetime" by using Monte Carlo simulation techniques. The major components of the model are an input/output worksheet, a fund accumulation worksheet, a fund withdrawal worksheet, a probability distribution worksheet and a pay table lookup worksheet. After completing 17 inputs and running a simulation, a user is able to determine the probability of achieving a specific amount of retirement savings as well as the probability associated with how many years the retirement savings, supplemented by military retirement benefits and Social Security, may last. The information gained by using the model allows military personnel to evaluate their current retirement plans and make necessary adjustments. Additionally, the model allows decision/policy makers to evaluate specific military retirement issues in order to determine how changes may affect service members.

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TABLE OF CONTENTS

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I. INTRODUCTION

A. PURPOSE

The purpose of this thesis was to develop a stochastic retirement planning model in order to allow individual users and decision-makers to evaluate retirement planning issues[1]. The model uses Monte Carlo simulation in order to associate probabilities to two planning forecasts, the amount of savings one may have at retirement and how long the retirement savings, supplemented by military retirement pay and Social Security benefits, may last. Knowing the probability associated with these two forecasts, military personnel and policy makers will be able to evaluate specific retirement planning issues.

B. BACKGROUND

An article in the San Francisco Chronicle titled "Why Online Retirement Calculators Give You the Wrong Numbers" highlights specific problems with using deterministic retirement planning models (Quinn, 1999, pp. D1). Most retirement planning calculators use an average estimate to approximate variables such as inflation and investment rates of return over time. Using these estimates, along with a user determined savings rate and the benefit of annual compounding, the deterministic planning model calculates a projected amount of retirement savings that "may often be far from the truth" (Quinn, 1999, pp. D1). The problem with most retirement planning calculators is that they use a reasonable average, generally based upon historical rates of

[1] The model was created using Microsoft Excel™ spreadsheet software and the Decisioneering, Inc. Crystal Ball™ add-in.

return. Should one project a 10 percent annual return per year, the deterministic model will project 10 percent return each and every year. However, investment rates of return vary from year to year and many times the variation can be quite large. One can look to a recent comparison between the 1999 NASDAQ percentage change of 85.5 percent and the current 2000 NASDAQ year to date percentage change of -28.6 percent to validate this point.[2]

A simple example will illustrate the problem highlighted by Quinn's article. Two individuals each invest $1000/year over a 10-year period and expect to achieve a 5 percent average return on their investment. Investor A enjoys a positive 20 percent return in years 1 through 5 and a negative 10 percent return in years 6 through 10 for an average return of 5 percent and his/her accumulated savings is $8,959 for which $10,000 was invested, a 10.4 percent loss. Investor B enjoys a negative 10 percent return in years 1 through 5 and a positive 20 percent return in years 6 though 10 for an average return of 5 percent and his/her accumulated savings have grown to $18,101, an 81 percent gain.

As shown by this example, the problem with using deterministic point estimates is that they do not capture the true uncertainty and variability of investment rates of return and inflation levels. Given that Investors A and B have earmarked these savings for retirement, Investor A may need to make some serious adjustments in order to have an adequate amount of retirement savings, while Investor B appears to be off to a good start.

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[2] The NASDAQ Index was 2192.69 on 31 December 1998, 4069.31 on 31 December 1999 and 2904.38 on 24 November 2000. The percentages shown were based upon these values.

The retirement planning efforts by most military personnel are not shielded from the uncertainty associated with investing their savings for retirement. Those reaching the milestone of 20 years of service, for which they are eligible for military retirement benefits, do have less of a concern, as some of their income needs are met by their military retirement pay. However investment and inflation uncertainty still exists.

This thesis will serve to develop a retirement planning model that accounts for the uncertainties surrounding inflation and investing in order to provide military members a means with which to evaluate their current retirement planning efforts as well as providing decision/policy makers a means of evaluating the potential impact of any changes they may make to the military retirement system.

C. RESEARCH QUESTIONS

The primary research questions are:

1. What is the probability associated with attaining a specific amount of retirement savings?
2. What is the probability of how many years the retirement savings, supplemented by military retirement benefits and Social Security, may last?

The subsidiary research questions are:

1. What are the benefits associated with the various military retirement plans?
2. What are the benefits associated with Social Security?
3. What are the rules and regulations for the various types of Individual Retirement Accounts?

4. What common investment options might military personnel choose to invest their retirement savings in?

5. How should military personnel allocate their invested retirement savings among the various investment options?

6. What are the historical rates of return, volatility and risk associated with the investment options and what is the historical rate of inflation?

7. From a statistical analysis standpoint, how are inflation and the investment option time-series data correlated?

D. SCOPE AND METHODOLOGY

The research methodology used in this thesis will consist of the following steps:

1. Conduct a literature search of books, magazine articles, CD-ROM systems, and other information resources, including the Internet, to obtain information relevant to retirement planning, the military retirement system, and the Social Security retirement system and to obtain historical data for variables involving uncertainty.

2. Analyze historical time-series data using statistical analysis techniques to determine relevant statistics such as mean, standard deviation and coefficient of variation and to determine the appropriate frequency distributions of the time-series data.

3. Develop a spreadsheet retirement planning model using Microsoft Excel(tm) using single point-estimates for input variables to calculate projected retirement savings and how long the savings may last given specific standard of living needs.

4. Replace single-point estimates with appropriate probability distributions using the Decisioneering, Inc. Crystal Ball(tm) add-in to and choose forecast cells.

5. Run simulations to determine the probability or certain level of meeting specific goals for various scenarios.

6. Evaluate the results of the simulations in order to identify potential areas of concern with respect to military retirement planning efforts and the decision maker's perspective.

E. ORGANIZATION OF STUDY

Chapter I identifies the focus and purpose of the thesis as well as the primary and secondary research questions.

Chapter II provides the reader and overview of the typical income sources available to military personnel.

Chapter III presents and analyzes the historical data gathered for this the thesis. It provides a "framework" for some investment options available to military personnel as well as some specific allocation recommendations to diversify one's investments.

Chapter IV presents the deterministic and stochastic planning models created using Microsoft Excel™ spreadsheet software and the Decisioneering, Inc. Crystal Ball™ add-in.

Chapter V presents some typical retirement planning scenarios facing military personnel and policy makers and evaluates the results of various Monte Carlo simulations using the stochastic model. Additionally, the chapter illustrates how "what-if" analysis can be done using the stochastic model.

Chapter VI presents the conclusions and recommendations of the thesis and provides areas for further research.

F. BENEFITS OF THIS THESIS

Similar stochastic retirement planning models are available from financial planners, but they cost up to $500 and their focus is not targeted to the military.[3] The stochastic retirement planning model created for this thesis was designed for the unique military retirement system and therefore should be much more useful and beneficial to military personnel and decision/policy makers.

[3] Reference is made to the Retirement Income Manager consultation offered by T. Rowe Price Associates, Inc.

II. TYPICAL RETIREMENT INCOME SOURCES AVAILABLE TO MILITARY PERSONNEL

A. INTRODUCTION

In general, military service members looking to fund their retirement needs will look to four sources of income, their military retirement benefits, Social Security benefits, their own retirement savings (typically Individual Retirement Accounts) and second-career pensions. This chapter will provide the reader an overview of the military retirement system, Social Security retirement system and Individual Retirement Accounts in order to gain an understanding of each system and to aid in retirement planning.

B. THE MILITARY RETIREMENT SYSTEM

Active duty personnel with 20 or more years of service are eligible for non-disability retirement pay under one of three military retirement plans. The three plans are commonly known as Final Pay, High-3, and REDUX.

Under each of the three plans, military retirement pay is calculated based upon a person's total years of service and a retirement pay multiplier. Additionally, retirement pay is tied to an inflationary measure in order to avoid a significant reduction in the purchasing power of military retirement income over time. This adjustment for inflation, called a Cost of Living Adjustment (COLA), is indexed to the Consumer Price Index (CPI).

1. Description of the Non-Disability Retirement Plans[4]

a) Final Pay method

This method applies to individuals who entered military service prior to 08 September 1980 and provides the highest amount of retirement pay of any of the three methods. Retirement pay is determined by the formula:

Monthly base pay at retirement * 2.5% * Number of years of active military service.

Annual COLA increases under this method equal the annual percentage increase in the CPI.

b) High-3 method

This method applies to individuals who entered military service on or after 08 September 1980, but before August 1, 1986 and provides the second highest amount of retirement pay under any of the three methods. Retirement pay is calculated as follows:

Average of the *highest three years* of basic pay * 2.5% * Number of years of active military service.

Annual COLA increases under this method are the same as the final pay method.

c) REDUX method (also known as the Military Retirement Reform Act of 1986)

This method applies to individuals who entered military service after 31 July 1986 and provides the least amount of retirement pay under any of the three methods. Retirement pay is determined as follows:

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[4] The calculations concerning military retirement pay have been greatly simplified to allow the reader to gain a general understanding to how the benefit is calculated. Persons desiring to know their exact retirement pay must consult their respective Personnel office.

Average of the highest three years of basic pay * (40% + 3.5% for each year over 20).

Under the REDUX plan, a one-time adjustment to retirement pay occurs when a retiree reaches age 62. The retirement pay multiplier is changed to 2.5 percent for each year of active service and an adjustment is made to the retirement pay such that retirement pay at age 62 for persons under the REDUX method equal that of those under the High-3 method. An example may illustrate the point more clearly. At age 62, the 20-year retiree under the REDUX method will begin receiving 50 percent of his or her average high three years base pay rather than 40 percent[5], and the 25-year retiree 62.5 percent rather than 57.5 percent[6].

REDUX COLA increases vary from that of the other two methods. The annual COLA increase equals the percentage increase in the CPI *minus* one percentage point (CPI – 1 percent). Therefore, persons under the REDUX method will have their retirement pay adjusted annually at CPI-1 percent, while those under the other two methods have their retirement pay adjusted by the full CPI percentage change.

2. Recent Changes Affecting REDUX Eligible Service Members

Effective 01 October 1999, service members who were previously eligible for the REDUX retirement plan are now confronted with two retirement plan options. The first option is to revert to the conditions of the High-3 plan for which they will receive increased retirement pay benefits over the REDUX plan. The second option is to receive a $30,000 retention bonus at the 15th year of service, agree to serve for a minimum of 20

[5] Calculated as 20 years * 2.5% or 50% versus 40%.

[6] Calculated as 25 years * 2.5% or 62.5% versus 57.5% (40% + 5 years * 3.5%).

years and remain under the conditions of the REDUX plan. The $30,000 bonus is considered taxable income in the year it is received, although, there are efforts to shield up to $10,500 of the bonus from taxes if invested in the new military Thrift Savings Plan (TSP). However, this effort has yet to be approved (OSD P&R, 2000, pp. 43).

3. Comparison of the Military Retirement Plans

Table 1 shows the comparative annual percentage increase in retirement pay a service member will receive from 20 to 30 years of service under the REDUX, High-3 and Final Pay plans.

Table 1. REDUX, High-3 and Final Pay Years of Service and Retirement Percentage Comparison

Years of Service	Percentage (REDUX)	Percentage (High-3 and Final Pay)[7]
20	40.0%	50.0%
21	43.5%	52.5%
22	47.0%	55.0%
23	50.5%	57.5%
24	54.0%	60.0%
25	57.5%	62.5%
26	61.0%	65.0%
27	64.5%	67.5%
28	68.0%	70.0%
29	71.5%	72.5%
30	75.0%	75.0%

[7] Although Final Pay and High-3 have the same percentage increase from 20 to 30 years of service, the base pay applied to the multiplier is computed differently as described in this thesis.

C. SOCIAL SECURITY RETIREMENT SYSTEM

Military members pay Social Security taxes, titled FICA on Leave and Earnings pay statements, and will generally earn enough Social Security credits during a military career to be eligible to receive Social Security retirement benefits. [8] The amount of retirement benefits is based upon one's average lifetime earnings, the number of retirement credits earned, and the age at which one chooses to retire. In general, higher earnings result in higher benefits. "The Social Security benefit for an individual aged 65 in 2000, who earned at least the FICA wage limit each year, is $1,433 per month" (Muksian, 2000).

The earliest someone may start receiving *reduced* Social Security retirement benefits is age 62 while the minimum age someone may receive *full* benefits is age 65. Due to changes in the laws governing Social Security, the full benefit age will gradually increase to age 67 based upon one's year of birth. Table 2 shows one's full retirement age based upon their year of birth (SSA, 1999, pp. 6).

Table 2. Social Security Full Retirement Age Based on Year of Birth[9]

Year of Birth	Full Retirement Age
1937 or earlier	65
1938	65 and 2 months
1939	65 and 4 months
1940	65 and 6 months
1941	65 and 8 months

[8] Persons born in 1929 or later need 40 credits (10 years of work) to be eligible for Social Security retirement benefits.

[9] This table has been reproduced from the Social Security Administration (SSA) Publication No. 05-10035.

1942	65 and 10 months
1943-1954	66
1955	66 and 2 months
1956	66 and 4 months
1957	66 and 6 months
1958	66 and 8 months
1959	66 and 10 months
1960 or later	67

In order to receive *increased* retirement benefits, a person may delay their retirement as late as age 70. For persons born in 1943 or later, the annual increase in benefits one may expect in delaying their retirement is approximately 8 percent (SSA Publication No. 05-10035, 1999, pp. 7). Table 3 shows the estimated maximum Social Security benefit for those who are between age 65 and 70 in year 2000 and have begun collecting benefits (Muksian, 2000). The table assumes that:

- The individuals have earned at least the FICA wage limits,
- The cost-of-living adjustment will be 2.4 percent yearly, and,
- The FICA wage limit will increase by 2.4 percent yearly.

Table 3. Monthly Social Security Delayed Benefits: Base Year 2000[10]

Age in 2000	Delayed Benefit Age					
	65	**66**	**67**	**68**	**69**	**70**
65	1,433	1,575	1,725	1,884	2,054	2,234
66		1,502	1,600	1,701	1,805	1,912
67			1,583	1,684	1,787	1,894
68				1,674	1,770	1,869
69					1,716	1,813
70						1,751

As with military retirement benefits, annual increases in Social Security retirement benefits are indexed to the CPI to avoid erosion of the real purchasing power of one's benefit over time.

In an effort to determine one's estimated Social Security retirement benefit, a "Request for Earnings and Benefit Estimate Statement", Form SSA-7004-SM, may be obtained from and mailed to the Social Security Administration. This form may also be downloaded from the Social Security Administration's website at http://www.ssa.gov/online/ssa-7004.pdf. An online request to obtain this statement may also be submitted electronically via the Internet at the same website at https://s00dace.ssa.gov/pro/batch-pebes/npping.cgi.

10 This table has been reproduced from the Muksian article, "Social Security Benefits at 65: Delay or Take the Money & Run".

D. INDIVIDUAL RETIREMENT ACCOUNT[11]

Individual Retirement Accounts (IRAs) are the third most common method in which military service members will be able to provide for their retirement income needs. There are two types of IRAs one may choose to utilize: a traditional IRA, or a Roth IRA.

A traditional IRA is a tax-deferred retirement account that is *also* tax-deductible under *certain* circumstances. A Roth IRA, first introduced in 1998, is a nondeductible retirement account that allows for tax-free withdrawals under *certain* conditions.

A discussion of the advantages and disadvantages of Traditional and Roth IRAs may assist one in gaining an understanding of each type of IRA and in deciding which to utilize.

1. Advantage and Disadvantages of Traditional and Roth IRAs

a) Advantages of Traditional IRAs

Tax Deferral Investment earnings compound tax-free year after year. This advantage allows an account to grow faster than it would if it were subject to annual taxes on income and capital gains.

Flexibility One may invest traditional IRA funds in virtually any type of financial investment such as, individual stocks, mutual funds, bonds, or money market accounts.

[11] In general terms, the information in this section was obtained from IRS publication 590, "Individual Retirement Arrangements."

Tax Deduction Contributions are tax-deductible if one is not an active participant in an employer-sponsored plan[12] or if the modified adjusted gross income is below a certain threshold.[13]

b) Disadvantages of Traditional IRAs

Penalties Penalties will be incurred if funds are withdrawn before age 59-1/2 or if an inadequate amount of funds are withdrawn after age 70-1/2.[14]

Taxes Withdrawn funds are subject to income tax on investment earnings and on the contributed amount if it was deducted initially. However, a long period of tax deferral and compounding may more than offset the taxes paid upon withdrawal.

c) Advantages of Roth IRAs

Tax-Free Withdrawals Unlike a traditional IRA, the Roth IRA allows for tax-free withdrawals if one is at least 59-1/2 years old and the account has been established for five or more years.

Flexibility As with a traditional IRA, one may invest Roth IRA funds in virtually any type of financial investment such as individual stocks, mutual funds, bonds, or money market accounts.

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[12] Military members are considered covered by an employer-sponsored plan.

[13] For 1999, the threshold was $31,000 for single filers and $51,000 for joint filers. Partial deductions were allowed on incomes up to $41,000 and $61,000, respectively.

[14] Persons reaching age 70-1/2 with Traditional IRA savings are required to take Required Minimum Distributions (RMD). In general terms, the RMD is calculated by dividing one's IRA savings balance on 31 December by one's single or joint life expectancy factor. Refer to IRS publication 590 "Individual Retirement Arrangements" for further details.

d) Disadvantages of Roth IRAs

Penalties As with a traditional IRA, penalties will be incurred if funds are withdrawn before age 59-1/2. However, unlike a traditional IRA, a Roth IRA does not require one to take minimum distributions upon reaching age 70-1/2 and older.

Taxes Contributions to a Roth IRA do not qualify for a tax deduction in the years the IRA is funded.

Conversions Should a traditional IRA be converted to a Roth IRA, income tax will be incurred on the converted amount for which taxes were not already paid. The taxes incurred in the year of conversion may be perceived as a disadvantage; however, the converted funds may now grow and be withdrawn tax-free after age 59-1/2.

2. Contributions and Withdrawals to IRAs

a) Traditional IRA Contributions

Anyone under age 70-1/2 who has earned income may contribute to a traditional IRA the lesser of $2,000 or 100 percent of their earned income. Married couples, regardless of a working or non-working spouse, may contribute a total of $4,000 into separate IRAs, provided their total earned income also exceeds $4,000. Neither spouse's IRA may receive more than $2,000 in annual contributions.

b) Traditional IRA Withdrawals

Funds withdrawn from a tax-deductible IRA before age 59-1/2 are subject to income tax plus an additional penalty tax of 10 percent. The penalty tax does not apply to money withdrawn under certain circumstances, such as for qualifying medical expenses, health-insurance premiums, higher-education expenses, or a first-time home purchase [15].

c) Roth IRA Contributions

Contributions up to $2,000 may be made each year to a Roth IRA under one of the following conditions:

- You are single and your modified adjusted gross income (AGI) is $95,000 or less. If one's modified AGI falls between $95,000 and $110,000, one's ability to contribute is gradually phased out.
- You are married, file a joint tax return, and their modified AGI is $150,000 or less. If a married couple's modified AGI falls between $150,000 and $160,000, their ability to contribute is gradually phased out.

Like a traditional IRA, annual contributions up to $2,000 may also be made to a Roth IRA for a *nonworking* spouse.

d) Roth IRA Withdrawals

Because contributions to a Roth IRA are made with after-tax dollars, one can withdraw contributions tax- and penalty-free at any time provided the account is more than five years old and one is at least age 59-1/2. A limited amount of funds may be withdrawn tax- and penalty-free for a first-time home purchase.[16]

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[15] Refer to IRS publication 590 "Individual Retirement Arrangements" for further details.

[16] Ibid.

If withdrawals are made from an account that is less than five years old, one must pay income tax on the withdrawal plus an additional penalty tax of 10 percent.

Unlike a traditional IRA, one need not take minimum distributions after age 70-1/2 and can continue to let funds grow tax-free. Beneficiaries of Roth IRAs are required to take minimum distributions.

E. SUMMARY

This chapter provided an overview of the most common retirement income sources available to military personnel. The sources include military retirement pay, Social Security retirement benefits and investment income from IRAs. Subsequent chapters will utilize this information in the construction of a stochastic retirement planning model.

III. INFLATION, INVESTMENT OPTIONS AND HISTORICAL DATA ANALYSIS

A. INTRODUCTION

Investment classes are commonly divided into common stocks, longer-term bonds, and short-term reserves such as U.S. Treasury bills (Vanguard, 1995, pp.19). Another common division is to describe stocks in terms of large- and small-company stocks, as these two groups have been shown to have significantly different historical returns and volatility. For purposes of this thesis, the investment classes will be described as small-company stocks, large-company stocks, intermediate-term U.S. Government bonds and U.S. Treasury bills, as this is how the data in the primary data reference source, Ibboston and Associates "Stocks, Bonds, Bills and Inflation XXXX[17] Yearbook" (or "SSBI Yearbook" for short) is arranged. The 1999 SSBI yearbook provides historical data on six different asset classes: (1) Large-company stocks, (2) Small- company stocks, (3) Long-term corporate bonds, (4) Long-term U.S. Government bonds, (5) Intermediate-term U.S. Government bonds, (6) U.S. Treasury bills and Inflation.

As the SSBI Yearbook provides historical data on *broad* investment classes, an individual investor may choose to invest in any number of *narrower* investment vehicles, such as individual stocks, mutual funds, money market funds, Certificates of Deposit or Corporate or U.S. Government bonds. Having an investment portfolio that is a "mix" of

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[17] As this is a publication that is revised annually, XXXX stand for the publication year. The most recent publication is 2000, which has historical data for the investment classes from 1926-1999.

the various investment options can be described as a diversified portfolio. In choosing how to invest one's retirement savings, financial consultants recommend a diversified portfolio in order to "reduce risk by purchasing a broad array of investments rather than a limited selection of individual securities." (Vanguard, 1995, pp. 18)

In this chapter, the reader will be introduced to inflation, various investment options, asset allocation guidelines, and an analysis of the historical data to be utilized in building a retirement planning spreadsheet model.

B. INFLATION

Inflation is defined as "an increase in the overall level of prices in the economy" (Mankiw, 1998, pp. 778). Inflation has the effect of reducing the power of one's income over time. For example, assuming an annual inflation rate of 3.5 percent, one would need $14,106 ten years from now to have the same purchasing power that $10,000 has today and one would need $19,898 in twenty years to equal $10,000 today. [18] Thus, the impact of inflation can have a detrimental effect on the purchasing power of one's income, especially, during retirement years when the ability to generate income is limited.

In reviewing the data at Appendix B, one can determine that it would take $9.14 in 1998 dollars to provide the same purchasing power that $1 had in 1925, again illustrating the detrimental effect inflation has on income. Figure 1 illustrates this graphically.

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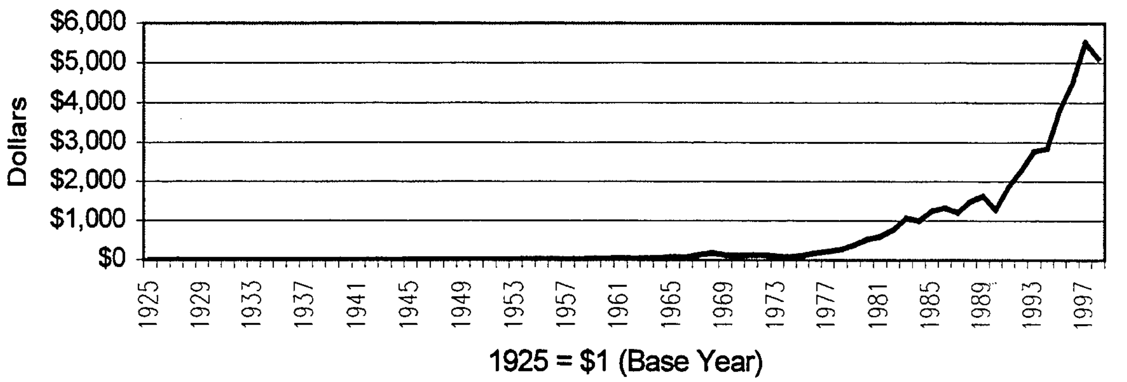
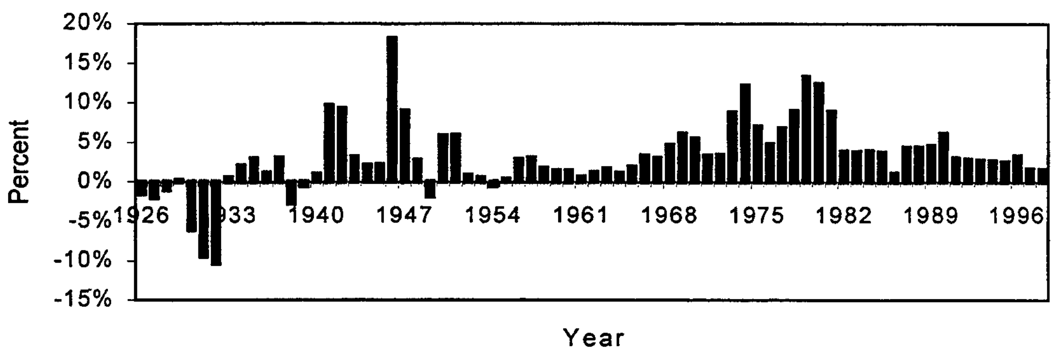
[18] The formula to calculate the future value an investment is: $FV = PV*(1 + r)^n$, where FV = future value, PV = present value, r = rate in percentage terms and n = number of periods. For the first example cited, the formula is $FV = \$10,000*(1 + 3.5\%)^{10}$.

Figure 1. Effects of Inflation on $1 Since 1925



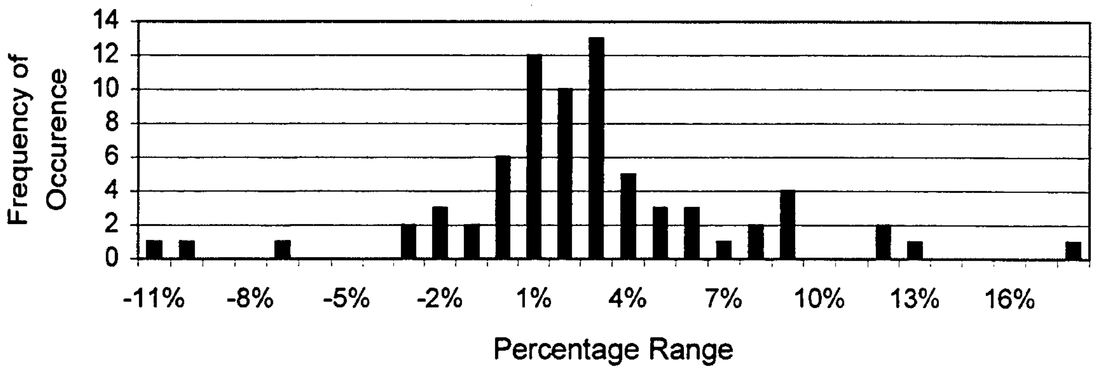
One of the most common measures of inflation is the Consumer Price Index (CPI) calculated by the Bureau of Labor and Statistics. Figure 2 graphically shows the annual percentage change in inflation from 1926-1998. The data used to create this graph can be reviewed at Appendix B.

Figure 2. Annual Inflation Rates 1926-1998



Additionally, the annual percentage change in inflation can be grouped into percentage ranges to determine the number of times, or frequencies of occurrence, the percentage change has been in a specific range. This grouping is called a frequency distribution. A graphical representation of a frequency distribution is called a histogram. Figure 3 shows the frequency distribution histogram for inflation in 1 percent increments.

Figure 3. Inflation Histogram from 1926-1998



As can be seen, inflation tends to cluster in the 1 percent to 5 percent range, yet it has been greater than 10 percent in 4 of the past 73 years and there have been periods of deflation in which inflation has been less than 0 percent in 10 of the past 73 years. Based upon historical data, inflation should fall between 1 percent and 5 percent six out of every ten times.

Using the data at Appendix B, one can also calculate some common descriptive statistics to describe inflation. The inflation average, or mean (μ), over the time period of 1926-1998 is 3.17 percent and the standard deviation (σ) is 4.45 percent. Standard deviation is a measure of the extent to which a distribution is grouped around the mean or spread out away from the mean. The smaller the standard deviation in a distribution, the more *all* the values will tend to cluster around the mean; the larger the standard deviation the more *all* the values will be distributed away from the mean. Since the distribution of the inflation data is approximately normal, approximately 68 percent of the historical values fall within one standard deviation around the mean of 3.17 percent, ranging from –1.3 percent to +7.7 percent. Additionally, approximately 90 percent of the values fall within two standard deviations and approximately 99 percent of the values fall within three standard deviations around the mean. Further insight concerning the importance of standard deviation will be discussed in the following section on small-company stocks.

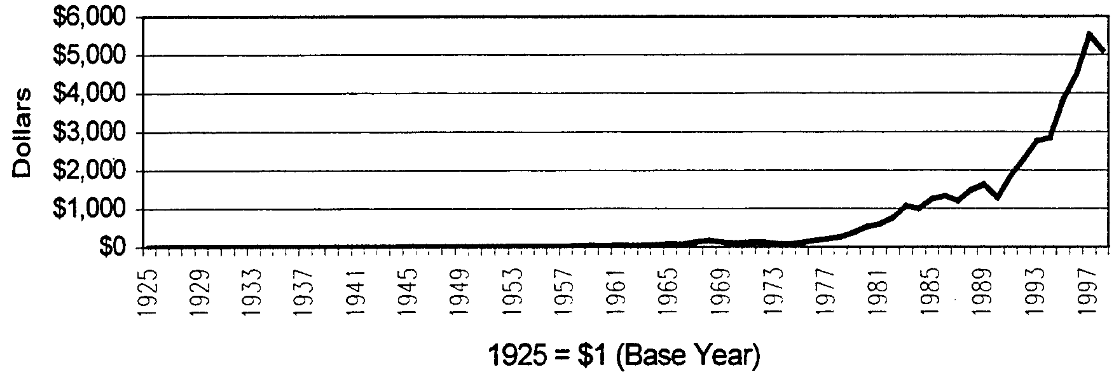
C. SMALL-COMPANY STOCKS

Many financial planners recommend that a portion of one's investments be invested in companies that are publicly traded on the major stock exchanges. Investing in stocks generally exposes one's invested capital to higher risk than the other investment options to be discussed. However, as will be discussed, historically stocks have afforded investors much greater investment rates of return than the other investment options.

One subset of investing in publicly traded company stocks is small-company stocks. There are numerous market indexes that track the performance of small-company stocks as a whole. One of the more common indices is the Russell 2000. The SSBI Yearbook has compiled historical small-company stock data in which small-companies are defined as the "stocks in the ninth and tenth deciles, in terms of market capitalization, of the stocks traded on the New York Stock Exchange (NYSE)" (Ibbotson, 1999, pg. 57). At the end of 1999, the weighted average market capitalization for NYSE stocks in the ninth and tenth decile was $230 million. (Ibid)

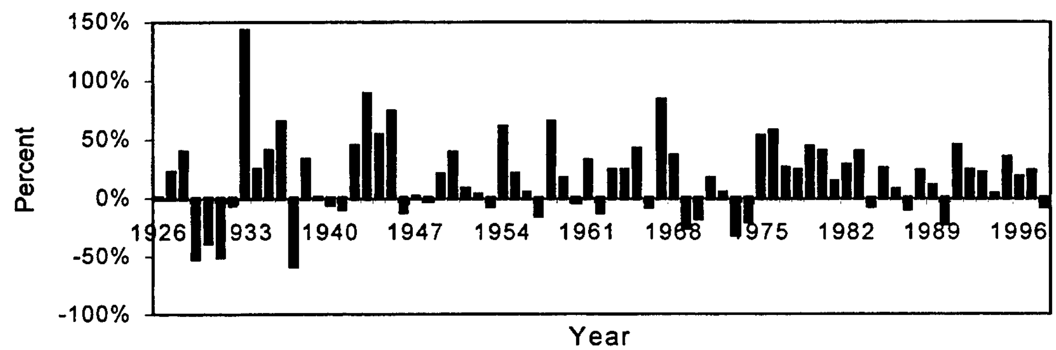
Historically, small-company stocks have provided average investment rates of return that have been far superior to that of other equity investment options. However, these superior returns have not been without a higher degree of risk. In reviewing the data at Appendix C, one can determine that $1 invested in small company stocks in 1925 would have grown to $5,116 in 1998, illustrating the substantial growth in small-company stock valuations. Figure 4 shows this graphically.

Figure 4. Growth of $1 Invested in Small-Company Stocks Since 1925



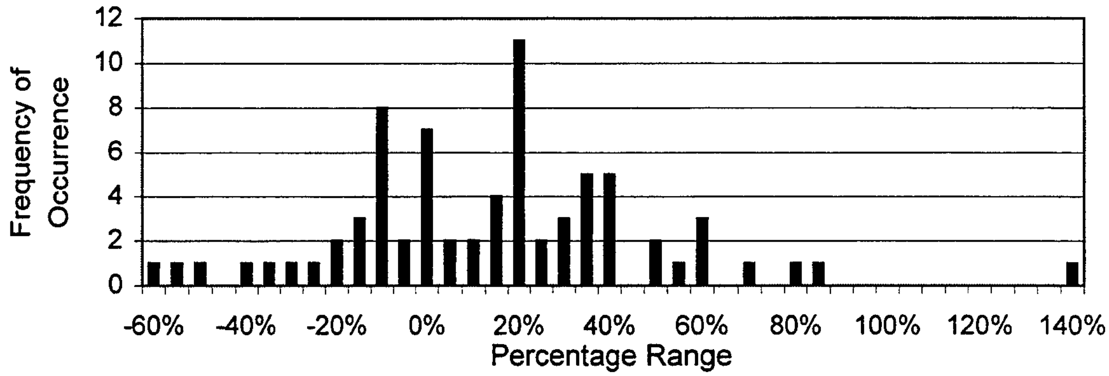
In reviewing the annual percentage change in small-company stocks at Appendix C, one can see their biggest gain occurred in 1933 with a 142.45 percent return over the prior year and their biggest loss was in 1937 with a -58.01 percent return. Figure 5 shows the annual percentage change in small-company stocks from 1926-1998.

Figure 5. Annual Small-Company Stocks Rate of Return 1926-1998



As Figure 5 shows graphically the annual small-company stock returns, one can aggregate the annual changes into a frequency distribution histogram. Figure 6 shows the frequency histogram for small-company stocks in 5 percent increments.

Figure 6. Small-Company Stock Histogram from 1926-1998



As depicted, the annual percentage returns for small-company stocks tend to cluster in the –10 percent to + 40 percent range. Small-company stock returns have been 20 percent or greater 36 of the 73 years and have had negative returns in 21 of the 73 years. The average return on small-company stocks during the period of 1926-1998 has been 17.4 percent, the standard deviation has been 33.8 percent and the Coefficient of Variation (CV) has been 1.94.[19]

In evaluating the risks of investing in small-company stocks or any other equity investment, the standard deviation and coefficient of variation provide some important insight concerning the riskiness of the investment. As stated previously, standard deviation is a measure of dispersion around the mean. An example will illustrate how standard deviation can be used to measure the relative risk of an investment. Consider two investments with the same 10 percent average rate of return, but different standard deviations, 10 percent for investment one and 20 percent for investment two. Investment one's standard deviation is smaller and therefore is less risky than investment two. This can be verified by calculating the coefficient of variation (CV) for each investment (see footnote 12):

Investment one = 10%/10% = 1,

Investment two = 20%/10% = 2.

The investment with the smaller CV is less risky. The ability to use standard deviation as a measure of risk comparison between two investments can only be applied if the investments have the same average rates of return. If the investments have different rates of return, the coefficient of variation must be calculated to determine which investment is more or less risky.

As an example, given two investments with the different average rates of return and different standard deviations, the way to determine which investment is more or less risky is to calculate the CV for each investment. Should investment one have an average return of 20 percent and standard deviation of 20 percent and investment two have an average return of 10 percent and a standard deviation of 15 percent, one would calculate the coefficient of variations:

Investment one = 20%/20% = 1.0,

Investment two = 15%/10% = 1.5.

Even though investment one has a higher standard deviation, its coefficient of variation is smaller than investment two, which means its risk is lower compared to investment two.

---

[19] Coefficient of Variation (CV) = Standard Deviation (σ)/Mean (μ) and shows the risk per unit of return. This provides a more meaningful basis for comparison when the standard deviation and mean vary between investments. (Brigham 157)

D. LARGE COMPANY STOCKS

In a similar fashion that one may choose to invest in small-company stocks, a second common subset of publicly traded company stock are large company stocks. For purposes of this thesis and the data presented, large-companies are defined as those companies that comprise the Standard and Poor's 500 (S&P 500). The S&P 500 Composite Index includes 500 of the largest stocks (in terms of stock market value) in the United States (Ibbotson, 1999, pp. 55). Some current stocks within the S&P500 index include General Electric Inc., Microsoft Inc., Ford Motor Company Inc., and International Business Machines Inc. (IBM).

One can see in Figure 7 and at Appendix D that $1 invested in 1925 would have grown to $2,351 by 1998. This demonstrates substantial growth, yet it is significantly lower than the growth shown by small-company stock investments.

Figure 7. Growth of $1 Invested in Large-Company Stocks Since 1925

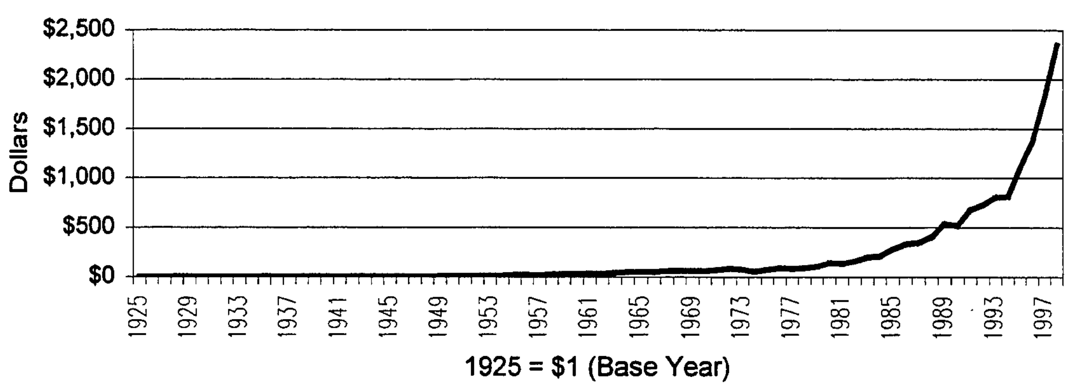
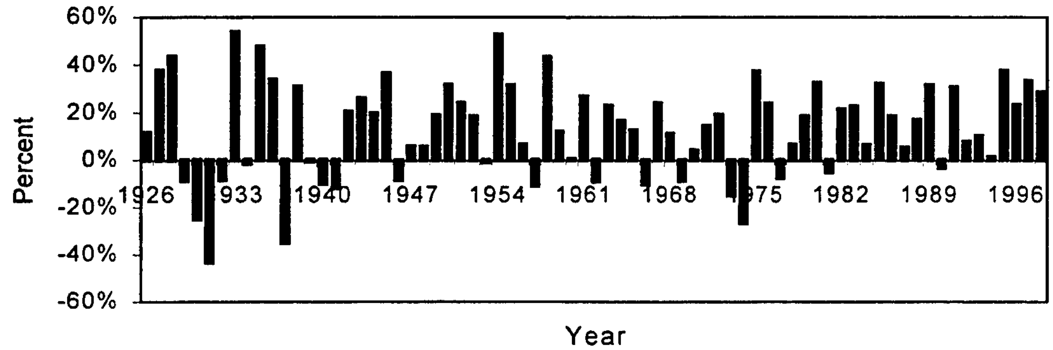


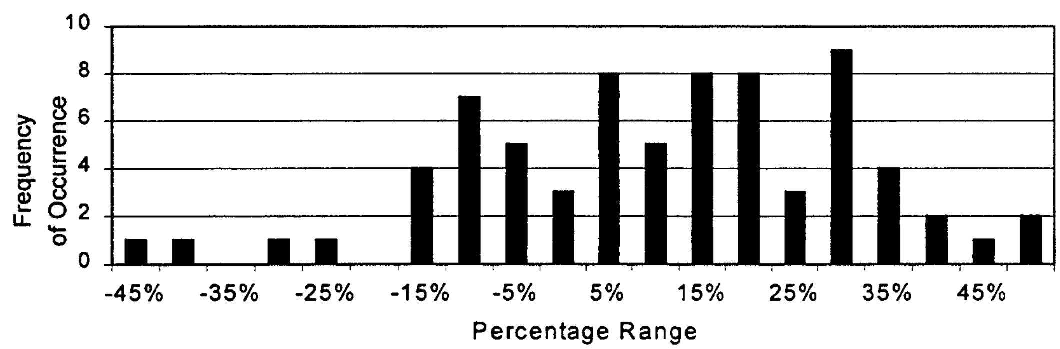
Figure 8 graphically shows the annual percentage change in large-company stocks from 1926-1998. The data used to create this graph can be reviewed at Appendix D.

Figure 8. Annual Large-Company Stocks Rate of Return 1926-1998



Aggregating the returns into a frequency distribution histogram, Figure 9 shows the frequency histogram for large-company stocks in 5% increments.

Figure 9. Large-Company Stock Histogram from 1926-1998



The percentage returns for large-company stocks tend to cluster in the –15 percent to +35 percent range. Large-company stock returns have exceeded 20 percent in 29 of 73 years and the returns have been 0 percent or less in 20 of 73 years. Their average return during the period of 1926-1998 has been 13.2 percent, the standard deviation has been 20.3 percent and the coefficient of variation has been 1.54. Investing in large-company stocks is relatively less risky than investing in small-company stocks. However, the likelihood of higher returns over time is also lower.

E. BONDS

Bonds are a form of debt issued by corporations and the U.S. Government. "A bond is a long-term contract under which a borrower agrees to make payments of interest and principal, on specific dates, to holders of the bond" (Weston and Brigham, 1987, pp. 286). Holders of bonds generally receive periodic interest payments and payment of the face value of the bond at its maturity date. In purchasing a bond, an investor essentially loans a government or corporation money in return for a set amount of interest at specific time intervals as well as repayment of the money loaned at the maturity date.

For purposes of this thesis, Intermediate-term U.S. Government bonds were chosen to be analyzed, as the historical data on this class of bonds was readily available from the SSBI Yearbook. Maturities for U.S. Government bonds can range from several months to 30 years. Intermediate-term U.S. Government bonds generally mature in about five years. Investing in bonds can be done in much the same manner as that of stocks, as bonds are publicly traded. One additional aspect to investing in Government bonds is that they can be purchased directly from the U.S. Government.

One can see at Figure 10 and from Appendix E that $1 invested in Intermediate-term U.S. Government bonds in 1925 would have grown to almost $44 by 1998. This growth is significantly lower than the growth provided by investing in small- or large-company stocks.

Figure 10. Growth of $1 Invested in Intermediate-Term U.S. Govt. Bonds Since 1925

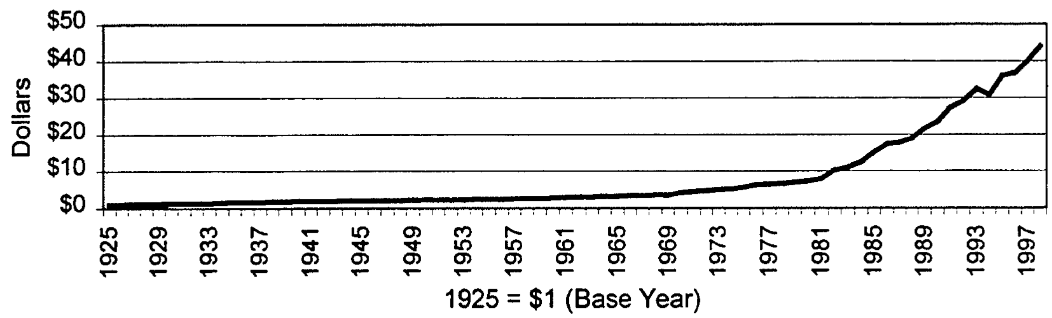


Figure 11 graphically shows the annual percentage change in Intermediate-term U.S. Government bonds from 1926-1998. The data used to create this graph can also be reviewed at Appendix E. One may note that, in general, these bonds have had only a limited number of years in which the return has been negative; however, the overall annual returns are much lower than those of large- or small company stocks.

Figure 11. Annual Intermediate-Term Government Bond Rate of Return 1926-1998

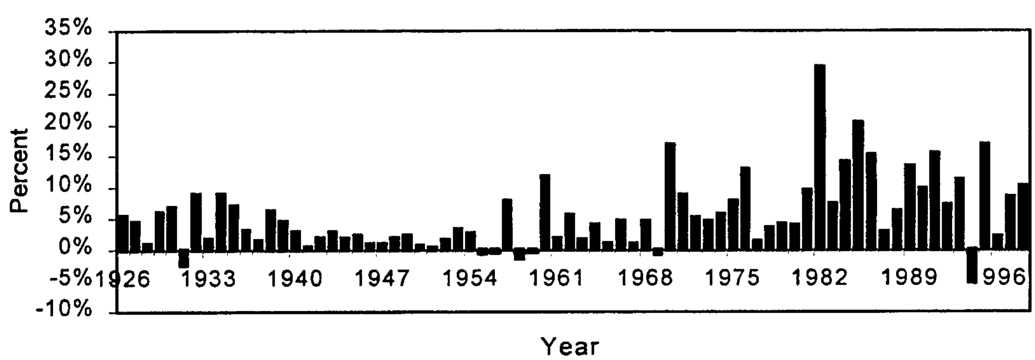
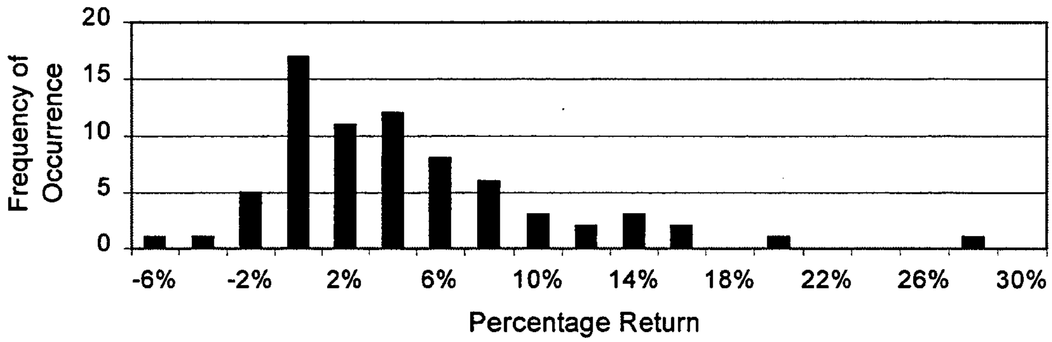


Figure 12 aggregates the annual returns into a frequency distribution histogram in 2 percent increments.

Figure 12. Intermediate-Term Government Bond Histogram from 1926-1998



The percentage returns for Intermediate-term U.S. Government bonds tend to cluster in the –2 percent to + 8 percent range. The average return on Intermediate-term U.S. Government bonds during the period of 1926-1998 has been 5.5 percent, the standard deviation has been 5.7 percent and the coefficient of variation has been 1.05.

F. TREASURY BILLS

U.S. Treasury bills, T-bills for short, are similar to bonds except they have very short maturity periods, generally, one month or less. T-bills are consider a "cash-like" or "cash-equivalent" investment in that they are very liquid and can be readily converted to cash when necessary. T-bills are considered to be one of the safest investments and have no risk of default. This factor becomes important as one is nearing or in retirement and will become evident in a section of this chapter that discusses asset allocation.

One can see in Figure 13 and at Appendix F that $1 invested in U.S. Treasury bills in 1925 would have grown to almost $15 by 1998, significantly lower than that of the other investment options.

Figure 13. Growth of $1 Invested in U.S. Treasury Bills Since 1925

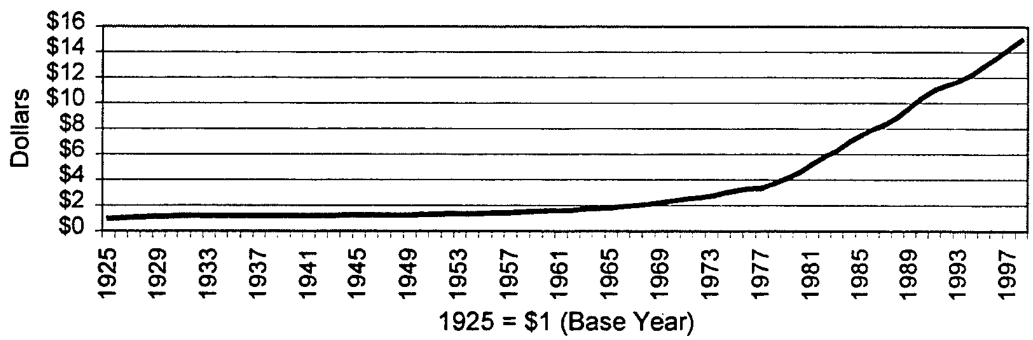


Figure 14 graphically shows the annual percentage change in U.S. Treasury bills from 1926-1998. The data used to create this graph can be reviewed at Appendix F.

Figure 14. Annual U.S. Treasury Bill Rate of Return 1926-1998

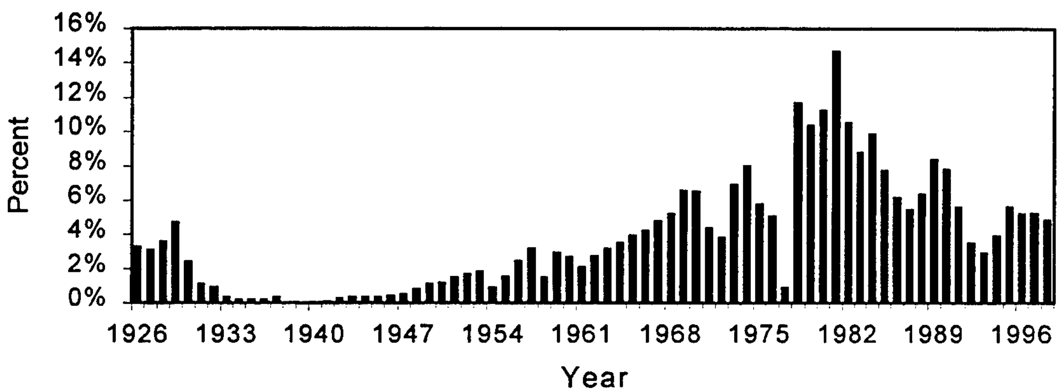
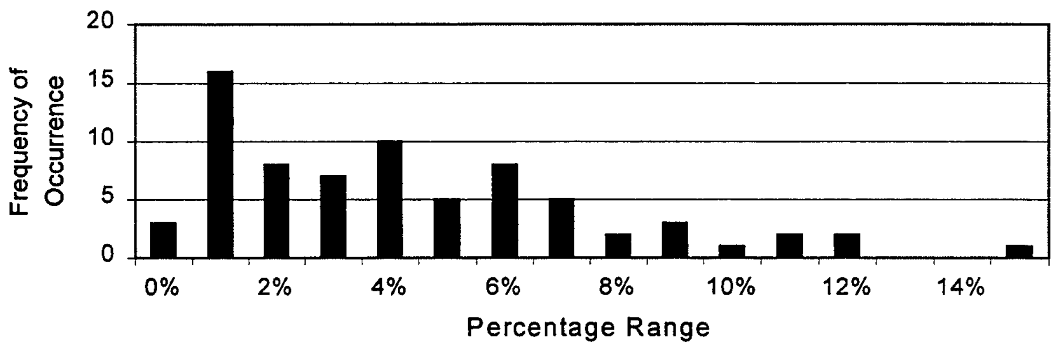


Figure 15 aggregates the annual returns into a frequency distribution histogram in 2 percent increments.

Figure 15. U.S. Treasury Bill Histogram from 1926-1998



The average return on U.S. Treasury Bills during the period of 1926-1998 has been 3.8 percent, the standard deviation has been 3.3 percent and the coefficient of variation has been 0.87. Investing in U.S. Treasury bills or other cash-like investments such as money market mutual funds generally will result in smaller returns than those of the other investment options. However, as they have the smallest coefficient of variation, they are considered the safest of the investment options.

G. SUMMARY OF INFLATION AND INVESTMENT OPTION RETURNS

The preceding sections of this chapter provided an overview of inflation and various investment options. In order to clarify and summarize the analysis, Table 4 shows the historical average return, standard deviation and coefficient of variation for inflation and the various investment options.

Table 4. Historical Average Returns, Standard Deviation and Coefficient of Variation for Stocks, Bonds, Bills and Inflation

Type	Average Annualized Return	Standard Deviation	Coefficient of Variation
Inflation	3.17%	4.45%	1.40
Small-Company Stocks	17.4%	33.8%	1.94
Large-Company Stocks	13.2%	20.3%	1.54
Intermediate-Term U.S. Govt. Bonds	5.5%	5.7%	1.05
U.S. Treasury Bills	3.8%	3.3%	0.87

In summary, small-company stocks have provided the greatest opportunity for higher rates of return, yet they also are the most risky of the various investment options followed by large-company stocks, Intermediate-term U.S. Government bonds and lastly U.S. Treasury bills.

H. ASSET ALLOCATION

There is a famous saying that states "Don't put all your eggs in one basket." This saying strongly applies to the tenets of diversification and asset allocation. As stated previously, financial consultants recommend a diversified portfolio in order to reduce investment risk. Along these lines, financial consultants have developed a framework, or guidelines, to aid investors in deciding how to allocate their investment funds. The general guidelines are summarized in Table 5 (Vanguard, 1995, pp. 81-84).

Table 5. Asset Allocation Guidelines

Accumulation Years (Age 20-49)	80% Stocks 20% Bonds
Transition Years (Age 50-59)	60% Stocks 40% Bonds
Early Retirement Years (Age 60-74)	40% Stocks 40% Bonds 20% Cash Reserves
Late Retirement Years (Age 75+)	20% Stocks 60% Bonds 20% Cash Reserves

One may choose to utilize these guidelines in making decisions on how to invest funds earmarked for retirement.

I. INVESTMENT HOLDING PERIODS

Investing in stocks can be volatile and one should only look to invest funds which can be invested for a significant period of time, generally five years or greater. Computing the moving average of the historical time series data for the various investment options discussed allows one to evaluate the rate of return for investments held for the length of the moving average time period. This section will look at the historical moving averages for the various investment options discussed previously in order to highlight the importance of maintaining a long-term investment strategy. Appendices H thorough K are an analysis of the five-, ten-, and twenty-year moving averages for small-company stocks, large-company stocks, Intermediate-term U.S. Government bonds, and U.S. Treasury bills. The moving averages were calculated from the raw data contained in Appendices C through F.

The five-year moving average is calculated by taking the returns in the previous five years and dividing by five, the ten-year moving average uses the returns in the preceding ten years and dividing by ten, and the twenty-year moving average uses the returns in the preceding twenty-years and dividing by twenty.

As an example, the five-year moving average for small-company stocks in 1930 is calculated:

1926	0.30%	(Excerpt from Appendix C)
1927	22.03%	
1928	39.71%	
1929	-51.35%	
1930	-38.10%	

1930 5-year moving average = (0.30 + 22.03 + 39.71 –51.35 – 38.10)/5 = -5.48% (agrees with 1930 5-year moving average at Appendix H).

Of particular interest in calculating the moving averages for each of the investment options is the minimum and maximum returns for each of the moving averages. The following table summarizes the analysis provided in Appendices G through J.

Table 6. Minimum and Maximum Percentage Returns for Various Holding Periods

Small-company Stocks: Holding Period

	1yr	5year	10year	20year
Max Return	142.45%	53.25%	31.73%	27.47%
Min Return	-58.01%	-20.97%	8.19%	11.86%

Large-company Stocks: Holding Period

	1yr	5year	10year	20year
Max Return	53.87%	25.18%	21.52%	18.00%
Min Return	-43.34%	-8.24%	2.51%	6.45%

Intermediate-Term Government Bonds:
Holding Period

	1yr	5year	10year	20year
Max Return	29.10%	17.20%	13.35%	10.03%
Min Return	-5.15%	1.02%	1.27%	1.60%

U.S. Treasury Bills:
Holding Period

	1yr	5year	10year	20year
Max Return	14.70%	11.71%	9.65%	7.76%
Min Return	0.00%	0.07%	0.15%	0.42%

The results shown in Table 6 indicate longer holding periods decrease the likelihood of experiencing negative returns. In fact, none of the investment options held for a minimum of 10 years had negative returns over the period of 1926-1998. This illustrates the benefits of a long-term investment strategy.

J. STATISTICAL CORRELATION OF HISTORICAL TIME SERIES DATA

In building a model that relies on historical time series data, it is important to determine if any of the time series data are cross-correlated and/or auto-correlated. Correlation is defined as the strength of association between two variables. Cross-correlation refers to the strength of association between two different variables, for example, inflation and small-company stocks or bonds and Treasury bills. Auto-correlation refers to the strength of association between one variable and the same variable offset by one or more periods. For example, the rate of inflation in one year may have an associative effect on the rate of inflation in the subsequent year (one-period time lag).

A common statistic that checks for cross-correlation between variables is Pearson's Correlation Coefficient. Pearson's Correlation Coefficient can range from -1.0

to +1.0. Where -1.0 represents perfect negative correlation, 0 represents no correlation, and +1.0 represents perfect positive correlation. If two variables are positively correlated, i.e., Pearson's Correlation Coefficient is greater than 0, when one variable is high, the other will also tend to be high, or when one variable is low, the other will tend to be low. The closer the coefficient is to +1.0, the stronger the positive correlation between the variables. Conversely, if two variables are negatively correlated, when one variable is high, the other will tend to be low and when one variable is low, the other will tend to be high. The closer the coefficient is to –1.0, the stronger the negative correlation between the variables.

The degree of auto- and/or cross-correlation should be significant to be included in a simulation model. For purposes of building a stochastic retirement planning model, variables that have a statistically significant correlation of ± 0.4 to ± 1.0 will be included in the model and the association between the variables will be "linked" with their corresponding correlation coefficient. Those variables that have a low degree of correlation, i.e., the correlation coefficient is between 0 and ± 0.4, will also be included in the model; however, they will be entered as uncorrelated variables. Appendix K. shows the analysis and results of the cross-correlation coefficients between the historical time series data: inflation, small-company stocks, large-company stocks, Intermediate-term U.S. Government bonds, and U.S. Treasury bills, as well as the analysis of the degree of auto-correlation exhibited by each time series variable. The analysis was conducted using Minitab, which is a widely used statistical analysis software with many features, including one that allows for the analysis of time-series data. A summary of the cross-correlation matrix and auto-correlation results is shown in Table 7.

Table 7. Pearson's Correlations Matrix and Autocorrelation Values

	Inflation	Small-company	Large-company	Bonds	Bills
Small-company	0.047 0.692				
Large-company	-0.028 0.811	**0.793** 0.000			
Bonds	0.009 0.942	-0.034 0.778	0.115 0.332		
Bills	**0.404** 0.000	-0.088 0.460	-0.010 0.935	**0.485** 0.000	
Autocorrelation	**0.642**	N/a	n/a	n/a	**0.851**

The upper value of the correlation matrix shown in Table 7 is the Pearson's Correlation Coefficient and the value below the coefficient is the known as the p-value. In this instance, the p-value is used to determine if the correlation coefficient is statistically significant. A p-value of 0.1 or less indicates the coefficient is statistically significant. As such, those values that have a correlation coefficient of ± 0.4 to ± 1.0 and are also statistically significant will be utilized in building the simulation model. The values meeting the criteria have been highlighted in bold.

K. SUMMARY

This chapter provided a detailed analysis of inflation and some investment options. The reader should have gained an understanding of the historical analysis for inflation, stocks, bonds and Treasury bills as well as the potential risks and returns possible by choosing to invest in any of the investment options. The historical frequency distributions and correlation ratios associated with the time-series data will be utilized in the following chapter in the construction of a stochastic retirement planning model.

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IV. DEVELOPMENT OF A DETERMINISTIC AND STOCHASTIC RETIREMENT PLANNING MODEL

A. INTRODUCTION

Utilizing the information from Chapters II and III, a retirement planning model using Microsoft Excel^{tm} was created to aid in evaluating one's retirement planning. The first model created was a deterministic model. A deterministic model is one in which each variable in the model can have only one value at a time. Users of a deterministic model can perform "what-if" analysis by changing one or more variables to evaluate how the results may change. "What-if" analysis may allow one to project a three level estimate.[20] However, the information obtained by doing so may still be inadequate as the user does not know with any level of certainty the likelihood of achieving the results generated.

In order to introduce the effects of uncertainty into the model, the deterministic model was expanded to allow variables, such as annual investment rates of return and inflation levels, to change based upon their probability distributions. This type of model is called a stochastic model. A stochastic model more accurately simulates reality and allows the user to associate a probability, or certainty level, with the model's results.

Using a deterministic model, a user may enter inputs and be led to believe that the result generated will in fact become reality. However, using a stochastic model, the user is able to associate a level of certainty, or probability, with the generated results. With

[20] The three-level estimate refers to the best case, worst case and most likely case for each variable in the model.

respect to retirement planning, knowing the probability of achieving a specific amount of retirement savings and the knowing the probability of how long the savings may last provides a great deal of information from which one can evaluate their current retirement planning efforts.

After reading this chapter, the reader will understand the construction of the deterministic and stochastic retirement planning models and will have been provided a detailed explanation of how the models work.

B. OBJECTIVES OF THE RETIREMENT PLANNING MODEL

In developing the retirement planning model, three objectives were formulated:

(1) Determine the amount of accumulated retirement savings as a result of user-defined inputs, such as current retirement savings and future savings plans;

(2) Determine the number of years retirement savings, supplemented by military and Social Security retirement benefits, may last as it is withdrawn to meet retirement income needs; and,

(3) Determine the associated probability distributions using Monte Carlo simulation to determine the certainty level of meeting the user's goals for objectives (1) and (2).

The use of spreadsheet software, such as Microsoft Excel™, easily facilitates creation of a model to answer objectives (1) and (2), while the use of simulation software, such as the Crystal Ball™ add-in, facilitates answering objective (3).

C. THE DETERMINISTIC RETIREMENT PLANNING MODEL

Microsoft Excel™ was used to create the deterministic retirement planning model. The first five pages of Appendix L contain a printout of the deterministic retirement planning model with hypothetical values input where necessary and will be used in explaining how the model is constructed.

In creating the retirement planning model, five individual, but interrelated, worksheets were created:

Worksheet 1: Input/Output,
Worksheet 2: Accumulation,
Worksheet 3: Withdrawal,
Worksheet 4: Pay Table Lookup,
Worksheet 5: Probability Data.

Worksheet 5 relates to the stochastic model and will be discussed in the Stochastic Retirement Planning Model section.

1. The Input/Output Worksheet

This worksheet is separated into four sections. Sections (1) through (3) are for user-specific input and section (4) provides output based upon the user's inputs. Table 8 provides a summary of the formulae used calculating outputs in this worksheet.

Table 8. Input/Output Worksheet Formulae

```
C25:  =SUM(C21:C24)
D25:  =IF(SUM(C21:C24)=100%,"","Must Equal 100%!")
C33:  =SUM(C29:C32)
D33:  =IF(SUM(C29:C32)=100%,"","Must Equal 100%!")
C36:  =IF(C10=3,40%+((C11-20)*3.5%),C11*2.5%)
C37:  =VLOOKUP(O35,PayTableLookup!A3:M29,P61+2)
C38:  =IF(OR(C10=3,C10=2),C37*C36*90%,C37*C36)
C40:  =VLOOKUP(C9,Withdrawal!A2:M47,8)/12
C41:  =VLOOKUP(C9,Withdrawal!A2:M47,9)/12
C42:  =VLOOKUP(C9,Withdrawal!A2:M47,10)/12
C44:  =VLOOKUP(C9-1,Accumulation!A2:P53,10)
C45:  =MAX(Withdrawal!A2:A47)-MIN(Withdrawal!A2:A47)
C46:  =IF(MIN(Withdrawal!M2:M47)<0,MAX(Withdrawal!A2:A47),
       "Unlimited")
```

The following discussion will explain how this spreadsheet is constructed and the calculations that occur. As a worksheet cell is referenced, the reader may need to refer back to Table 8, and subsequent tables, to review the formula for the referenced cell.

a) The User Input Section

Section (1) of this worksheet pertains to the user's personal information. Cells C8-C12 allow the user to make a selection from a drop down menu. The inputs required here are self-explanatory.

At cell C13, the user is asked to enter their "Anticipated Future Monthly Needs In Current Dollars." Many financial consultants recommend that one's retirement income needs may be reduced to as low as 70 percent of their current income requirements. For example, if a person requires $5,000/month to maintain a certain lifestyle in their pre-retirement years, they may be able to maintain nearly the same lifestyle in their retirement years on 70 percent of that income, or $3500/month. This rule-of-thumb is a subjective choice each user must make. For this scenario, $5,500/month was chosen.

Cell C14 asks the user to enter their estimated Social Security Retirement benefits. Users can obtain this estimate directly from the Social Security Administration (SSA). Recall from the overview on Social Security benefits, that "the Social Security benefit for an individual aged 65 in 2000, who earned at least the FICA wage limit each year, is $1,433 per month" (Muksian). For this example, the user entered $1,100/month.

Sections (2) and (3) allow the user to enter specific information concerning their pre-retirement and retirement savings. The inputs for cells C17 and C18 are self-explanatory. Cell C19 allows the user to project an annual percentage increase in the yearly savings going towards retirement. In this example, the user projected a 2 percent annual increase. By doing so, the user is anticipating that they will be able to continually increase their contribution going towards retirement savings by 2 percent annually.

Financial planners typically recommend that younger persons should assume greater investing risk in order to reap higher returns and to reduce risk exposure near or after retirement. Therefore, sections (2) and (3) each have an "Investment Savings Allocation" section in which the user can determine how their pre- and post-retirement investments will be allocated among stocks, bonds, and money market accounts. This again is a subjective choice each user must make based upon their level of risk tolerance and investment decisions. For this scenario, the allocation during pre-retirement years is 50 percent small-company stocks, 30 percent large-company stocks and 20 percent bonds and the allocation during the retirement years is 20 percent small-company stocks, 30 percent large-company stocks, 30 percent bonds and 20 percent money market accounts. These allocations will be used to determine the amount of earnings the retirement savings make each year on the Accumulation and Withdrawal worksheets.

b) The Output Information Section

Section (4) calculates some deterministic outputs based upon the user-defined inputs in sections (1) through (3). The first output, cell C36, is the "Retirement Pay Multiplier." This is calculated based upon the inputs at cell C10, the user-selected military retirement plan, and at C1, the planned number of years of service. The formula in cell C36 accounts for the differences in the various retirement plans discussed in chapter II. The calculation occurs as follows. Cell C10 contains a value 1, 2, or 3 which correspond to the military retirement plan selection of Final-pay =1, High-3=2, and REDUX =3. If the value in cell C10 equals 3, then the IF( ) function in the formula determines the criteria C10=3 to be TRUE and the first argument , 40%+(C11-20)*3.5%, is used. Should the IF( ) function determine the criteria C10=3 to be FALSE, then the second argument, C11*2.5%, is used. As the user in this scenario selected REDUX, the value in cell C10 equals 3 and the first argument is used. The calculation is 40%+(22-20)*3.5% which equals 47.0 percent, the result shown at cell C36.

The second output, cell C37, is the "Current Monthly Base Pay for Retirement Rank and YOS." Based upon the user inputs, the output is determined by use of the VLOOKUP function. The VLOOKUP function is used to find the intersection of the user's Retirement Rank and Years of Service at the Pay Table Lookup worksheet. In this scenario, the user plans on retiring with 22 years of service at the rank of 0-5 (Commander or Lieutenant Colonel); see cells C12 and C11 respectively. The VLOOKUP function uses these two selections and goes to the Pay Table Lookup worksheet to retrieve the value at the intersection of 0-5 (row 8) and 22 (column E), which is $5,752, the result shown at cell C37.

The third output, cell C38, provides an estimated monthly military retirement benefit in current dollars according to the applicable retirement plan selected. If the user selected the REDUX or High-3 retirement plan in cell C10, the criterion is evaluated as TRUE and the result at cell C38 is determined by the first argument, C36*C37*90%. If the user selects the Final pay retirement plan option in cell C10, then the criteria is evaluated as FALSE and the result at cell C38 is determined by the second argument, C36*C37. As the user in this scenario, selected REDUX, the first argument is used. The calculation is 47%*$5,725 which equals $2,433, the result shown at cell C38.

Why multiply the product of cells C36 and C35 by 90 percent for the REDUX and High-3 retirement pay options to determine one's estimated monthly military retirement benefit? Recall that retirement pay benefits for the REDUX and High-3 retirement plans are based upon the average of the highest three years of earnings, generally the final three years of service. In order to obtain an estimate of what one's retirement benefit would be based upon the highest three years of earnings, one source indicates that taking 90 percent of monthly base pay in the final year of service will suffice (Navy Times 33). For purposes of this thesis, this approximation is considered to be more than adequate.

Cells C40-C42 present inflation-adjusted projections for one's monthly income needs, monthly military retirement benefit and Social Security pension based upon the values in cells C13, C37, and C14 respectively. Using the VLOOKUP function, the formula takes the desired full retirement age at cell C9, 67 in this example, and retrieves the respective inflation-adjusted values from the Withdrawal worksheet. As these values are expressed in annual terms, they are divided by 12 to convert to monthly values and displayed as the results shown at cells C40-C42, $15,892, $7,912, and $3,616 respectively.

Cell C44 displays the projected amount saved at retirement. This value is retrieved from the Accumulation worksheet using the VLOOKUP function. Here the

VLOOKUP function uses the value in cell C9 minus one, or 66 in this example, to determine the final accumulation year on the Accumulation worksheet, then retrieves the value from column 10 of the Accumulation worksheet and displays this as the result shown, $4,269,269.

Cell C45 displays the projected number of years the retirement savings will last. The Excel MAX( ) and MIN( ) functions determine the maximum value and minimum value in the array A2:A47 at the Withdrawal worksheet. Here the minimum value is determined to be 67 and the maximum value is 101, the difference is 34, shown as the result at cell C45.

Finally, cell C46 shows the age of the user that the savings are projected to last. The formula in this cell looks at the array M2:M47 of the Withdrawal worksheet to evaluate if the minimum value of the array is less than zero. If the minimum value is less than zero, the retirement savings will be depleted at some time in the future and the first argument is used to determine the age at which this occurs. If the minimum value in array M2:M47 is zero or greater, then the second argument, Unlimited, is displayed as the result. The term, Unlimited, is used to account for a situation in which the retirement savings will not be depleted. This is the case in this scenario.

2. The Accumulation Worksheet

The purpose of the Accumulation worksheet is to calculate the user's accumulated savings up to the year before retirement as well as the inflation-adjusted monthly values for retirement needs, military retirement income and Social Security retirement income. Table 9 provides a summary of the formulae used in this worksheet.

Table 9. Accumulation Worksheet Formulae

A2:	=Input_Output!C8
A3:A53:	=IF(OR(A2>Input_Output!$C$9-1, A2=Input_Output!$C$9-1),"",A2+1)
B2:	=Input_Output!C17
B3:B53:	=IF(A3="","",J2)
C2:C53:	=IF($A2="","",VLOOKUP($A2,ProbabilityData!$A$2:$F$88,2))
D2:D53:	=IF($A2="","",VLOOKUP($A2,ProbabilityData!$A$2:$F$88,3))
E2:E53:	=IF($A2="","",VLOOKUP($A2,ProbabilityData!$A$2:$F$88,4))
F2:F53:	=IF($A2="","",VLOOKUP($A2,ProbabilityData!$A$2:$F$88,5))
G2:G53:	=IF($A2="","",VLOOKUP($A2,ProbabilityData!$A$2:$F$88,6))
H2:H53:	=IF(A2="","",B2*G2*Input_Output!$C$24+B2*F2* Input_Output!$C$23+B2*E2*Input_Output!$C$22+B2*D2* Input_Output!$C$21)
I2:	=IF(A2="","",Input_Output!C18)
I3:I53:	=IF(A3="","",I2*(1+C3)*(1+Input_Output!$C$19))
J2:J53:	=IF(A2="","",B2+I2+H2)
K2:	=Input_Output!C13
K3:K53:	=IF(A3="","",K2*(1+C3))
L2:	=Input_Output!C37*(40%+(Input_Output!P62-20)*3.5%)*0.9
L3:L53:	=IF(OR(A3="",A3>62),"", L2*(1+C3-1%))
M3:M53:	=IF(A3="","",IF(AND(A3=62,Input_Output!$C$10=3),N3, IF(M2="","",M2*(1+C3-1%))))
N2:	=IF(Input_Output!C10=1,Input_Output!C37* (Input_Output!P62*2.5%),Input_Output!C37* (Input_Output!P62*2.5%)*0.9)
N3:N53:	=IF(A3="","",N2*(1+C3))
O2:O53:	=IF(OR(Input_Output!$C$10=1,Input_Output!$C$10=2),N2, IF(M2="",L2,M2))
P2:	=Input_Output!C14

The reader should note absolute and relative cell referencing applies to these formulae. For example, the formula for cells A3:A53 is expressed as:

=IF(OR(A2>Input_Output!$C$9-1,A2=Input_Output!$C$9-1),"",A2+1)

This is the actual formula in cell A3. Subsequent formulae in cells A4 to A53 change based upon relative referencing. For example, the formula in cell C4 changes to:

=IF(OR(A3>Input_Output!$C$9-1,A3=Input_Output!$C$9-1),"",A3+1)

This use of absolute and relative referencing is used throughout the retirement planning model.

The Accumulation worksheet starts with cell A2 to obtain the user's current age from cell C8 of the Input/Output worksheet, 33 in this example. The formulae for cells A3:A53 increment the age by one year until reaching the year before the user's desired retirement age input at cell C9 of the Input/Output worksheet. In this example, the age is incremented yearly to age 66. The cells will expand or contract to reflect the user's age specification.

Moving to cell B2, the worksheet obtains the beginning amount the user has in retirement savings from cell C17 of the Input/Output worksheet, in this case, $10,000.

Cells C2:G53, use the VLOOKUP function to obtain values for the historical average for inflation and average rate of return for the various investment options from the Probability Data worksheet. The link between these worksheets is necessary for the implementation of the stochastic planning model to be discussed later in this chapter. Suffice it to say that, for the deterministic model, the values in cells C2:G53 remain constant as shown on the Probability Data and Accumulation worksheets. These values will vary according to the specified probability distribution in the stochastic planning model.

The annual earnings in cell H2 are calculated based upon the beginning balance at cell B2, the investment savings allocation from cells C21-C24 of the Input/Output worksheet and the average rates of return in cells D2-G2. For this scenario, recall the following values from the Pre-Retirement Investment Allocation section of the Input/Output worksheet:

Input_Output!$C$24	0%	(Bills),
Input_Output!$C$23	20%	(Bonds),
Input_Output!$C$22	30%	(Large-company stocks),
Input_Output!$C$21	50%	(Small-company stocks).

Also note the following annual percentage returns from cells D2-G2:

D2	17.38% (Small-company return),
E2	13.17% (Large-company return),
F2	5.47% (Bond return),
G2	3.83% (Money-market return),

and the beginning balance of $10,000 in cell B2.

For this scenario, the result in cell H2 is determined by:

$10,000*3.83%*0%+$10,000*5.47%*20%+$10,000*13.17%*30%+$10,000*17.38%*5
0%

which equals $1,374 shown. Each successive computation in column H follows the same logic.

Cell I2 obtains the annual retirement savings contribution from cell C12 of the Input/Output worksheet, in this scenario $4,000. Each successive cell in column I adjusts for inflation and the annual percentage increase the user entered in cell C19 of the Input/Output worksheet, in this case a 2 percent annual increase. For example, the result in cell I3 is calculated as $4,000*(1+0.0317)*(1+0.02) which equals $4,209 shown.

The ending balances in column J are determined by the addition of the beginning balance for the year (column B), the earnings on the beginning balance (column H) and the annual contribution (column I). One assumption made in the logic of this worksheet was that the annual contribution was not made until the end of the period and as such would not generate any investment earnings until the next investment year. The ending balance in column J moves to the beginning balance for the next investment year in column B. For example, note the beginning balance of $15,374 in cell B3 equals the ending balance in cell J2 of the prior year. The successive computations in determining the annual earnings, contribution and ending balance follow the same logic as that described above. In the example shown, the computations repeat until reaching the final accumulation year at age 66, the year prior to the desired retirement age, at which time the user is projected to accumulated $4,269,269 in retirement savings shown at cell J35. This agrees with the value presented in cell C44 of the Input/Output worksheet.

Column K calculates the inflation-adjusted monthly income needs and column P calculates the inflation-adjusted Social Security benefit based on the value input by the user at cells C13 and C14 of the Input/Output worksheet. Each successive value is adjusted by the respective rate of inflation in column C. For example, the result in cell K3 is determined by $5,500*(1+0.0317) which equals $5,674 shown.

The inflation-adjusted monthly military retirement income is shown at column O. The values shown at column O are taken from the values in column L, M, or N depending on the retirement plan selected by the user on the Input/Output worksheet.

The computation of the monthly military retirement income was somewhat complicated as a result of the one-time adjustment that occurs at age 62 for retirees under the REDUX system, as is the case in the scenario presented. REDUX retirement pay is determined by the inflation-adjusted values shown in column L. However, at age 62, the REDUX retiree receives a one-time adjustment to their retirement pay, which is adjusted to equal the retirement pay they would be receiving had they been under the High-3 plan. For this scenario, the monthly REDUX retirement pay at age 62 is adjusted to $7,038 instead of $4,535. This adjustment is a one-time "catch-up" feature of the REDUX retirement plan. From age 63 and beyond, the REDUX retiree's retirement pay continues to be adjusted by CPI-1 percent while the High-3 retiree's retirement pay is adjusted by CPI.

Cell N2 calculates the inflation-adjusted retirement pay for those under either the Final pay or High-3 plans. The Final-pay retirement benefit is computed as 100 percent of the monthly base pay at cell C37 of the Input/Output worksheet multiplied by the number of years of service at cell C11 of the Input/Output worksheet times 2.5 percent. The High-3 retirement pay is computed as 90 percent of the Final-pay benefit in order to estimate the average of the highest three years base pay as discussed previously. Each successive value in column N is adjusted by the rate of inflation.

3. The Withdrawal Worksheet

The purpose of the Withdrawal worksheet is to determine how long the user's retirement savings will last. Table 10 provides a summary of the formulae used in this worksheet.

Table 10. Withdrawal Worksheet Formulae

A2:	=MAX(Accumulation!A2:A53)+1
A3:A47	=IF(OR(M2<0,M2=""),"",A2+1)
B2:	=VLOOKUP(A2-1,Accumulation!A2:K53,10)
B3:B47	=IF(OR(M2<0,M2=""),"",M2)
C2:C47	=IF($A2="","",VLOOKUP($A2,ProbabilityData!$A$2:$F$88,2))
D2:D47	=IF($A2="","",VLOOKUP($A2,ProbabilityData!$A$2:$F$88,3))
E2:E47	=IF($A2="","",VLOOKUP($A2,ProbabilityData!$A$2:$F$88,4))
F2:F47	=IF($A2="","",VLOOKUP($A2,ProbabilityData!$A$2:$F$88,5))
G2:G47	=IF($A2="","",VLOOKUP($A2,ProbabilityData!$A$2:$F$88,6))
H2:	=VLOOKUP(A2-1,Accumulation!A2:P53,11)*12*(1+C2)
H3:H47	=IF(OR(M2<0,M2=""),"",H2*(1+C3))
I2:	=VLOOKUP(A2-1,Accumulation!A2:P53,15)*12*(1+C2)
I3:I47	=IF(OR(M2<0,M2=""),"",IF(Input_Output!$C$10=3,I2*(1+C3-1%),I2*(1+C3)))
J2:	=VLOOKUP(A2-1,Accumulation!A2:P53,16)*12*(1+D2)

J3:J47 =IF(OR(M2<0,M2=""),"",J2*(1+C3))
K2:K47 =IF(OR(M1<0,M1=""),"",H2-I2-J2)
L2:L47: =IF(OR(M1<0,M1=""),"",(B2-H2)*G2*Input_Output!$C$32+(B2- H2)*F2*Input_Output!$C$31+(B2-H2)*E2*Input_Output!$C$30+(B2-H2)*D2*Input_Output!$C$29)
M2:M47 =IF(OR(M1<0,M1=""),"",B2-K2+L2)

An assumption made in creating this worksheet is that the user will cease making any further contributions to their retirement savings once they enter their retirement years.

The logic within this worksheet is very similar to that of the Accumulation worksheet. Starting at cell A2, the user's retirement age is determined. Each subsequent cell in column A increments the age by one year as long as the ending balance in column M is zero or greater.

Cell B2 uses the VLOOKUP function to retrieve the final ending balance from column J of the Accumulation worksheet. This value, $4,269,269 in this scenario, is the amount of savings that the user has amassed as they enter retirement.

Cells C2:G47 contain the same links to the Probability Data worksheet and values for inflation and investment rates of return as discussed in the Accumulation worksheet section.

Cell H2 uses the VLOOKUP function to retrieve the final inflation-adjusted monthly retirement need from column 11 of the Accumulation worksheet and converts this to an annual requirement by multiplying the value retrieved by 12. The result is also adjusted by the rate of inflation in cell C2. Each successive value in column H is adjusted by the respective rate of inflation in column C. For example, the result in cell K3 is determined by $190,704*(1+0.0317) which equals $196,750 shown.

Columns I and J use the same logic as that of column H in retrieving the final inflation-adjusted military retirement income and Social Security income from columns 15 and 16 of the Accumulation worksheet. Each successive value in columns I and J are adjusted by the respective rate of inflation in column C.

Column K determines the net amount to be withdrawn from savings by taking the annual income requirement less the funds provided by the military retirement and Social Security benefits. An assumption in the model is that these funds are withdrawn from the beginning balance before the retirement savings begin to earn investment income for the year.

The annual earnings in cell L2 are calculated based upon the beginning balance at cell B2, the investment savings allocation from cells C29-C32 of the Input/Output worksheet and the average rates of return in cells D2-G2. For this scenario, recall the following values from the Retirement Investment Allocation section of the Input/Output worksheet:

Input_Output!$C$32	20% (Bills),
Input_Output!$C$31	30% (Bonds),
Input_Output!$C$30	30% (Large-company stocks),
Input_Output!$C$29	20% (Small-company stocks).

Also note the following annual percentage returns from cells D2-G2:

D2	17.38% (Small-company return),
E2	13.17% (Large-company return),
F2	5.47% (Bond return),
G2	3.83% (Money-market return),

and the beginning balance of $4,269,269 in cell B2.

For this scenario, the result in cell L2 is determined by:

($4,269,269 -$52,306)*3.83%*20%+($4,269,269 -$52,306)*5.47%*30%+($4,269,269 -$52,306) *13.17%*30%+($4,269,269 -$52,306) *17.38%*20%

which equals $401,086 shown. Each successive computation in column L follows the same logic.

The ending balances in column M, or the remaining retirement savings, are determined by taking the beginning balances in column B, subtracting the net retirement savings withdrawal from column K and adding the annual earnings from column L. The worksheet will continue to determine the yearly ending balance until the retirement savings are depleted or it reaches the final computation in cell M47. In the scenario presented, the retirement savings are projected to continue to increase and will not be depleted. This is a function of the inputs the user entered for this scenario. Given the results presented under this scenario and in using the deterministic model, the user may choose to modify some of the initial input variables, such as increasing their projected monthly income needs to determine what effect that has on the overall results. This approach, although somewhat beneficial, still does not provide the user with a certainty level, or probability, for each scenario they investigate. This is where the application of Monte Carlo simulation will provide the user more valuable information from which to base their retirement planning decisions.

4. The Pay Table Lookup worksheet

This worksheet contains no formulae and its sole purpose is to provide a table from which the VLOOKUP function in cell C37 of the Input/Output worksheet can retrieve the monthly base pay associated the user's desired retirement rank and years of service. Since this is a retirement planning model, the relevant range of service length is 20 to 30 years. The method in which the VLOOKUP function retrieves the correct base pay for a particular rank and years of service was reviewed at the Input/Output worksheet section. The data in this table is current as of July 2000. In the future, the user can update this table as new Pay Tables are published.

D. THE STOCHASTIC RETIREMENT PLANNING MODEL

Retirement planning deals with future events, which inevitably involve uncertainty. Development of a stochastic retirement planning model, allowing users to evaluate their current retirement planning decisions in a probabilistic term, is the focal point of this thesis.

In evaluating how to construct a viable stochastic retirement planning model, the variables in the deterministic model were reviewed to determine which variables involve uncertainty and should be represented by probability distributions. Recall that in the deterministic model, the historical average, or mean, was used to represent the expected, or most likely, value for inflation, small-company stocks, large-company stocks, bonds and money market accounts. In actuality, the inflation level and rate of return on investments vary greatly from year to year.

The use of the Crystal Ball[tm] add-in for Microsoft Excel[tm] provides a means to associate a probability distribution with the inflation and investment option variables in the deterministic model. Recall that cells D2:G53 on the Accumulation worksheet and cells D2:G36 on the Withdrawal worksheet contain a formula similar to

=IF($A2="","",VLOOKUP($A2,ProbabilityData!$A$2:$F$79,3))

This formula used the VLOOKUP function to retrieve the corresponding value for inflation and investment rates of return for a particular year from the Probability Data worksheet. In the deterministic model, these values remained constant. In a stochastic model using Monte Carlo simulation techniques, these variables change based upon their respective probability distributions for each trial in a simulation. Referring to Appendix L, the reader is directed to the last five pages. These pages show the probability distribution functions for Inflation, Small-company stocks, Large-company stocks, Intermediate-term U.S. Government bonds and Treasury Bills (shown as Money Market funds). Using the Crystal Ball™ add-in, the probability distribution function was entered into each cell for each variable on the Probability Data worksheet.

In entering a probability distribution into a worksheet cell, Crystal Ball™ allows the user to select from one of 17 different distributions. Some of the more common distribution choices are Normal, Poisson, Binomial, Lognormal, Beta, Exponential and Hypergeometric. Also, Crystal Ball also allows the user to enter a custom distribution. For this thesis, custom distributions were used for each variable based upon their historical frequency distributions discussed in Chapter II. The historical frequency distributions for each variable shown at Appendix L can be compared to the frequency distributions discussed in chapter II. The distributions are the same.

Another feature of Crystal Ball™ allows the user to enter correlation ratios between variables. Recall from the correlation discussion in chapter II that the time series data for inflation and the various investment options exhibited a degree of auto- and cross-correlation that was significant enough to be considered when constructing a stochastic model. Using Crystal Ball™, the variables shown on the Probability Data worksheet have been "linked" with the degree of correlation discussed in chapter II. The reader may review the correlation ratio used to "link" each variable at Appendix L shown above the graphic for each variable.

In running a simulation using the stochastic model created, Crystal Ball^{tm} allows the user to select the number of trials to be used in the simulation. For the stochastic retirement planning model, each trial will represent one "lifetime" in which the user accumulates savings during their pre-retirement years and withdraws them during their retirement years. The Crystal Ball^{tm} add-in allows the user to create Forecast cells. After each trial, the add-in retrieves the value of the forecast cell and uses them to generate the probability distribution for the forecast cells.

For this thesis, the objectives were to know the probability of achieving a specific amount in retirement savings and how long the retirement savings will last to support the desired living standard. Referring to the Input/Output worksheet, cells C44 and C45 are defined as the forecast cells. In evaluating how many trials to run, the user must choose a sufficient number such that the probability distributions for the forecast cells stabilize. Another method is to continue the simulation until the standard error of the mean is sufficiently smaller than the mean. In general it is desirable to have less than 1 percent error. These factors are something that must be evaluated as the simulation is run.

E. SUMMARY

This chapter described the construction of a deterministic and stochastic retirement planning model. With the stochastic planning model, the user can run various simulations in order to achieve the objective of knowing the associated probability of how much retirement savings they may accumulate during the pre-retirement years and how long the retirement savings may last. The next chapter will provide the results of a Monte Carlo simulation using the Crystal Ball[tm] add-in and illustrate the benefits in using the stochastic retirement planning model.

V. STOCHASTIC RETIREMENT PLANNING MODEL SIMULATION RESULTS AND ANALYSIS

A. INTRODUCTION

Having reviewed the construction of the deterministic and stochastic retirement planning models, this chapter will review and analyze the results of various simulations. The chapter will highlight the benefits of using the stochastic retirement planning model from both an individual perspective and from the perspective of decision and policy makers. Some typical retirement scenarios facing individuals and/or decision makers will be created and the results of the simulations will be evaluated.

The first scenario to be analyzed will be from an individual perspective. The scenario presented will be a continuation of the example provided in chapter IV. The second scenario presented will be from a policy maker perspective and will attempt to espouse the benefits of service members serving in the military beyond 20 years while demonstrating the adequacy of the military retirement system.

B. RESULTS AND ANALYSIS OF A SIMULATION FROM AN INDIVIDUAL PERSPECTIVE

Recall from chapter IV the following scenario:

a) 33 Year Old U.S. Navy Lieutenant,

b) Desired Full Retirement Age is 67,

c) Currently under the REDUX Military Retirement Plan (entered service after 31 July 1986),

d) Plans to Retire from the Military as an 0-5 with 22 YOS,

e) Anticipated Future Monthly Needs in Current Dollars of $5,500,

f) Estimated Social Security Benefit in Today's Dollars of $1,100,

g) Current Retirement Savings of $10,000,

h) Planned Annual Retirement Savings Contribution of $4,000,

i) Anticipated Increase in Retirement Savings Contribution of 2 percent Annually,

j) Pre-Retirement Investment Savings Allocation of 50 percent Small-company Stocks, 30 percent Large- company Stocks and 20 percent Bonds,

k) Retirement Investment Savings Allocation of 20 percent Small-company Stocks, 30 percent Large-company Stocks, 30 percent Bonds and 20 percent Money Market Funds.

The results of the deterministic model indicated that the service member would have $4,269,269 in retirement savings and the savings would last for at least 45 years.

Using the simulation model, the Lieutenant desires to answer the following three questions:

1) What amount of retirement savings can be anticipated with a 90 percent probability, or certainty level?

2) What is the probability of the retirement savings, supplemented by military retirement and Social Security benefits, lasting 30 years or longer?

3) What is the probability of accumulating the $4.2M in retirement savings indicated by the deterministic model?

After running the simulation, the Lieutenant was able to obtain answers to his questions.[21]

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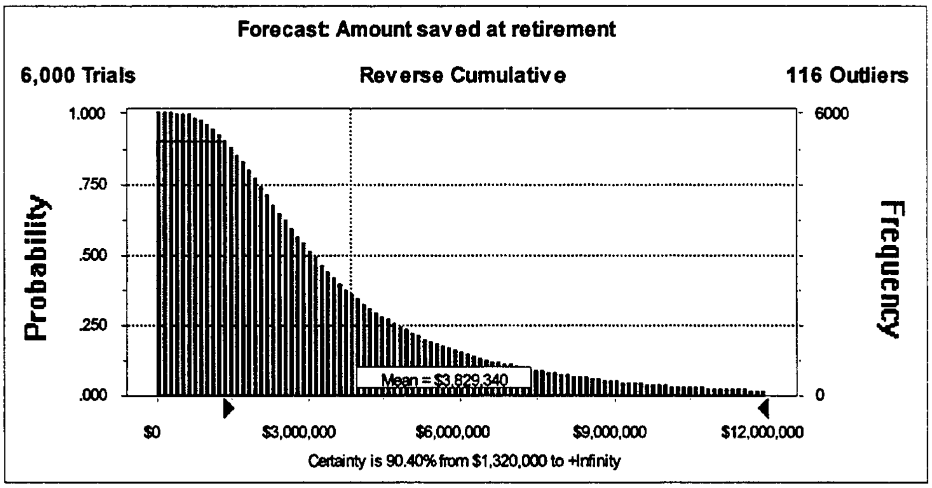
[21] A complete report of the simulation can be reviewed at Appendix M.

As can be seen in Figure 16, the graphical output from the Crystal Ball™ add-in, there is a 90 percent probability of accumulating at least $1,320,000 in retirement savings (the leftmost triangle on the x-axis indicates $1,320,000).[22]

Figure 16. Cumulative Frequency Graph for Amount Saved at Retirement



Next, the Lieutenant desired to know the probability associated with the retirement savings lasting for 30 years or longer. The graphical result of this question is shown at Figure 17.

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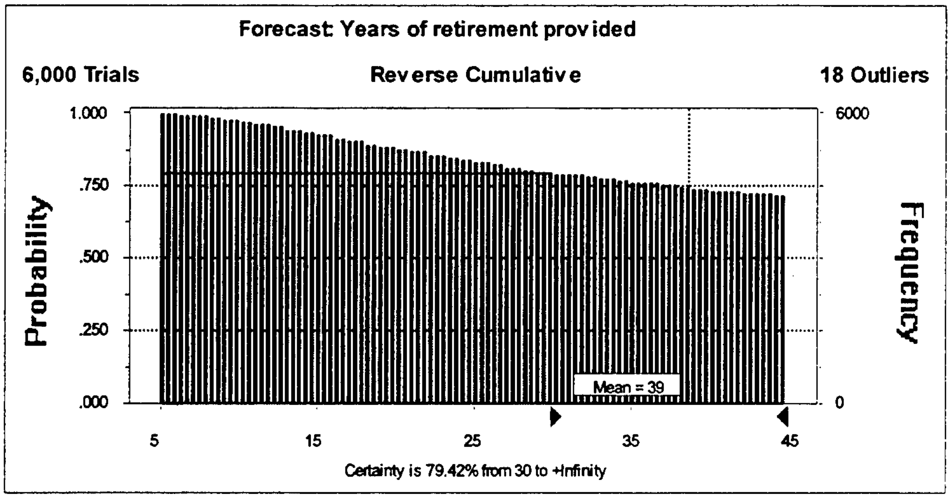
[22] The reader may be interested to note that the graphical output from the Crystal Ball™ add-in is dynamic. While reviewing the output, the user can quickly use the computer mouse to move what Crystal Ball calls a "grabber" to see how the probability changes for any desired forecast value. For instance, should the Lieutenant want to know the amount of savings he may accumulate with an 80% probability, he could obtain the answer to this question very quickly by moving the leftmost grabber and reading the result of $1.78M.

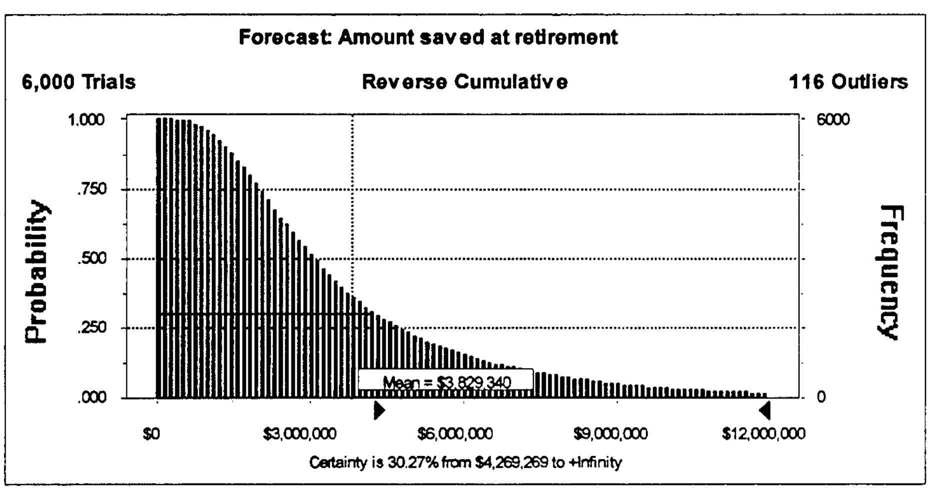
Figure 17. Cumulative Frequency Graph for Year of Retirement Savings Provided



The result from the model estimates that there is an 80 percent probability that the retirement saving will last at least 30 years.

Lastly, the Lieutenant wanted to determine the probability of achieving the $4.2M predicted by the deterministic retirement planning model. The result shown at Figure 18 indicates there is *only* a 30 percent probability, or a 1 in 3 chance, that the retirement savings will grow to the amount predicted by the deterministic model.

Figure 18. Cumulative Frequency Graph for Amount Saved at Retirement



The information gained in running one simulation may prove to be very beneficial to the user in evaluating their current retirement plans. However, the model can also be expanded to perform "what-if" analysis.

1) What-if Analysis Using the Stochastic Model

In addition to obtaining the results described above, one may desire to know the effect of changing one of the input variables has on the simulation results. This can be done by performing "what-if" analysis, in which one input variable is modified at a time, running the simulation again, and analyzing the results.

For instance, the Lieutenant in the scenario under review may be interested in knowing how the following changes may alter his retirement outlook:

1) If he reverts to the High-3 retirement plan, how long might his retirement savings last?

2) What would be the effect of reducing the risk exposure to the pre-retirement savings by changing the allocation to 10 percent Small-company stocks, 30 percent Large-company Stocks and 60 percent Bonds?

After changing the inputs to the initial scenario one at a time, and running the simulation, the Lieutenant is able to determine answers to his "what-if" questions: [23]

1) By reverting to the High-3 retirement plan, there is an 80 percent probability that the retirement savings will last 44 or more years. This is significantly longer than the 30 years predicated by the initial simulation.[24]

[23] A complete report of the what-if results can be reviewed at Appendix M under the headings Question 1 Result and Question 2 Result.

2) By changing the pre-retirement investment allocation as described, there is a 90 percent probability of accumulating $885,000 in retirement savings and *only* a 49 percent probability that the retirement savings will last 30 years or greater.

With the information gained from the "what-if" analysis, the Lieutenant may determine it is in his best interest to revert to the conditions of the High-3 retirement plan. However, unless he maintains a pre-retirement savings plan as initially discussed, the probability of the retirement savings lasting for 30 or more years is greatly diminished.

The intent of this section was to demonstrate the benefits of the simulation model from an individual user's perspective. The scenarios and follow-on "what-if" analysis one can generate from an individual perspective are endless. However, by using the stochastic retirement planning model a user can quickly and easily evaluate their current retirement planning effort and determine the effect changes may have on meeting their desired retirement goals.

C. RESULTS AND ANALYSIS OF A SIMULATION FROM A POLICY MAKER PERSPECTIVE

Use of a stochastic retirement planning model does not only benefit the individual military member in evaluating one's retirement planning effort, it can also prove beneficial to policy and decision makers. For example, given that a military member makes a modest but concerted effort to save for their retirement, a policy maker may be

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24 Recall in the initial simulation, there was an 80% probability that the retirement savings would last 30 years or longer. 80% is used here to make a "apples-to-apples" comparison.

interested in knowing whether or not the retirement benefits afforded to military members are adequate.

The following scenario may assist the policy maker in evaluating this question. This scenario describes an enlisted member with 10 years of service (YOS) who is at a "crossroad" of whether or not to stay in the military for a career or discontinue military service:

a) 30 Year Old Female Second Class Petty Officer (E-5) with 10 YOS,

b) Desired Full Retirement Age is 65,

c) Currently under the REDUX Military Retirement Plan (entered service after 31 July 1986),

d) Plans to Retire from the Military as a Chief Petty Officer (E-7) with 20 YOS,

e) Anticipated Future Monthly Needs in Current Dollars is $2,500,

f) Estimated Social Security Benefit in Today's Dollars is $1,000,

g) Current Retirement Savings is $0,

h) Anticipated Annual Retirement Savings Contribution of $1,000,

i) Anticipated Annual Increase in Annual Contribution of 1 percent,

j) Pre-Retirement Investment Savings Allocation is 50 percent Small-company Stocks, 30 percent Large- company Stocks and 20 percent Bonds,

k) Retirement Investment Savings Allocation is 10 percent Small-company Stocks, 30 percent Large-company Stocks, 40 percent Bonds and 20 percent Money Market Funds.

After entering the above inputs into the stochastic model and running a simulation, the results indicate there is a 90 percent probability the Petty Officer Second Class will accumulate almost $280,000 in retirement savings and a 90 percent probability that the retirement savings will last *only* 12 or more years.[25] With this information, the policy maker may determine that the retirement benefits are inadequate and, as such, the Petty Officer may decide to discontinue military service. However, by performing additional "what-if" analysis to see the effect of choosing to stay in the military for 25 years has on the results, the policy maker may change his opinion.

By changing the Years of Service input variable to 25 vice 20, and running the simulation again, the policy maker is able to determine there is still a 90 percent probability the Petty Officer Second Class will accumulate almost $280,000 in retirement savings. However more importantly, there is now a 90 percent probability that the retirement savings will last for 33 years or longer.[26]

With this additional information the policy maker may be able to advise the service member that by maintaining a modest retirement savings plan and choosing to stay in the military for longer than 20 years their retirement goal can be met with a high probability of success. Doing so turns out to be beneficial to both the service member as they are able to meet their retirement goals by making a career of the military and the military, which benefits through increased retention and morale.

The intent of this section was to demonstrate how the stochastic retirement planning model benefits policy and decision makers. Just as there is uncertainty with an individual's retirement planning efforts, there is uncertainty in how the military's retirement policies may affect service members. Through the use of the stochastic

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[25] A complete report of the simulation can be reviewed at Appendix N.

[26] A complete report of the what-if results can be reviewed at Appendix N under the heading "What-if" Result.

retirement planning model, decision makers are able to evaluate, from a probabilistic standpoint, the impact of their policy decisions and can use this information in advocating the benefits of a military career.

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VI. SUMMARY

A. SUMMARY

Uncertainty exists in retirement planning. A great deal of information, both in print and online, is available to aid persons in their retirement planning efforts. However, the majority of the information looks at retirement planning from a deterministic perspective. Most retirement planning calculators ask the user to provide their "best guess" estimate, generally based upon historical averages, as to what inflation and investment rates of return will be in the future. As this thesis has explained, the year-to-year change in inflation and investment rates of return vary widely. Providing a single point-estimate does not capture the true reality and uncertainty surrounding retirement planning and can lead the users of a deterministic retirement planning model to believe in an output or result that may far from the truth.

The intent of this thesis was to develop a stochastic retirement planning model that allows users to evaluate their retirement planning efforts from a probabilistic viewpoint and thereby mitigate uncertainty in retirement planning. As the thesis has shown, the use of a stochastic model provides the user a great deal of information from which they can evaluate their retirement plans. In using the model, one can gain a much better understanding as to how one's current retirement planning efforts may allow them to achieve their retirement goals.

The various scenarios the model can simulate are infinite; however, the output allows one to determine if their current retirement planning effort is either adequate or inadequate. For example, the model may point out to the user that their current retirement planning effort is not adequate for the desired standard of living and one may need to make changes to their retirement savings plans in order to meet one's goal. Some specific changes may be to increase savings now, defer military retirement in order to obtain an increased military retirement benefit, or defer full retirement in order to achieve a higher probability of meeting one's retirement goals. The user can evaluate the impact of these changes by doing "what-if" analysis and rerunning the simulation.

Conversely, the model may point out to the user that their current retirement planning efforts are more than adequate. As such, the user may be able to look towards a higher standard of living during retirement then initially planned or the user may be able to reduce their current retirement planning effort and use current funds for more current needs such as a child's education or to purchase a home. Here too, the user can perform "what-if" analysis and rerun the simulation to evaluate the impact of changes to their retirement plans.

A secondary goal of this thesis was to develop a tool that may prove to be beneficial to policy and decision makers when dealing with military retirement issues. As the thesis illustrated, one benefit may be in demonstrating how continuing service past 20 years may greatly improve a service member's chances of meeting one's retirement goals. Another potential use may be in evaluating how changes to the military retirement system may affect the retirement goals of the men and women serving in the military. Here again, the possible scenarios are endless.

It is the author's hope that the ability to look at retirement planning issues from a probabilistic viewpoint using the stochastic planning model will be of great benefit to individual service members and policy/decision makers alike.

B. PROPOSED AREAS FOR FUTURE RESEARCH

1. Further research can be conducted in order to develop additional investment options to be built into the stochastic retirement planning model such as growth and value stocks or corporate bonds.

2. Further research can be conducted to determine if there is an "optimal" mix of investments that would provide for maximizing investment returns while minimizing portfolio risk in using the stochastic retirement planning model.

3. Further research, can be conducted in order to incorporate actuarial table data so users of the model may assess the probability of achieving his/her retirement goal for his/her life expectancy.

4. As the military Thrift Saving Plan becomes effective, further research can be conducted to determine how incorporating this into the stochastic retirement planning model may affect one's retirement planning goals.

5. Lastly, further research can be conducted to determine how the second career that most military retirees pursue affects one's retirement plans and how the stochastic model could be improved upon to account for the second career options.

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APPENDIX A. JULY 2000 MILITARY PAY TABLE

YEARS OF SERVICE	<2	2	3	4	6	8	10	12	14	16	18	20	22	24	26
COMMISSIONED OFFICERS															
O-10	0	0	0	0	0	0	0	0	0	0	0	10655	10708	10930	11318
O-9	0	0	0	0	0	0	0	0	0	0	0	9319.5	9453.6	9647.7	9986.4
O-8	6594	6810	6953	6993	7172	7472	7541	7825	7906	8150	8504	8830.2	9048	9048	9048
O-7	5480	5852	5852	5894	6115	6282	6476	6669	6863	7472	7985	7985.4	7985.4	7985.4	8025.6
O-6	4061	4462	4754	4754	4772	4977	5004	5004	5169	5791	6086	6381.3	6549	6719.1	7049.1
O-5	3248	3814	4078	4128	4292	4292	4421	4659	4972	5286	5436	5583.6	5751.9	5751.9	5751.9
O-4	2738	3334	3556	3606	3812	3980	4253	4464	4611	4759	4809	4808.7	4808.7	4808.7	4808.7
O-3	2544	2884	3113	3365	3526	3703	3850	4040	4139	4139	4139	4139.1	4139.1	4139.1	4139.1
O-2	2219	2527	2911	3009	3071	3071	3071	3071	3071	3071	3071	3071.1	3071.1	3071.1	3071.1
O-1	1926	2005	2423	2423	2423	2423	2423	2423	2423	2423	2423	2423.1	2423.1	2423.1	2423.1
COMMISSIONED OFFICERS WITH OVER 4 YEARS ACTIVE DUTY SERVICE AS AN ENLISTED MEMBER OR WARRANT OFFICER															
O-3E	0	0	0	3365	3526	3703	3850	4040	4200	4292	4417	4416.9	4416.9	4416.9	4416.9
O-2E	0	0	0	3009	3071	3169	3334	3461	3556	3556	3556	3556.2	3556.2	3556.2	3556.2
O-1E	0	0	0	2423	2588	2684	2781	2878	3009	3009	3009	3009	3009	3009	3009
WARRANT OFFICERS															
W-5	0	0	0	0	0	0	0	0	0	0	0	4475.1	4628.7	4782.9	4937.4
W-4	2592	2789	2869	2948	3083	3217	3353	3485	3622	3754	3888	4019.4	4155.6	4289.7	4427.1
W-3	2356	2555	2555	2588	2694	2815	2974	3071	3177	3298	3419	3539.1	3659.4	3780	3900.9
W-2	2063	2233	2233	2306	2423	2555	2653	2750	2844	2949	3056	3163.8	3270.9	3378.3	3378.3
W-1	1719	1971	1971	2136	2233	2333	2433	2533	2634	2735	2835	2910.9	2910.9	2910.9	2910.9
ENLISTED MEMBERS															
E-9	0	0	0	0	0	0	3015	3083	3170	3272	3373	3473.4	3609.3	3744	3915.9
E-8	0	0	0	0	0	2528	2602	2670	2752	2840	2933	3026.1	3161.1	3295.5	3483.6
E-7	1766	1928	2001	2073	2148	2221	2294	2367	2439	2514	2588	2660.4	2787.6	2926.2	3134.4
E-6	1519	1678	1753	1824	1899	1973	2047	2119	2192	2245	2283	2283.3	2285.7	2285.7	2285.7
E-5	1333	1494	1566	1640	1715	1790	1862	1936	1936	1936	1936	1936.2	1936.2	1936.2	1936.2
E-4	1243	1373	1447	1520	1594	1594	1594	1594	1594	1594	1594	1593.9	1593.9	1593.9	1593.9
E-3	1172	1261	1334	1336	1336	1336	1336	1336	1336	1336	1336	1335.9	1335.9	1335.9	1335.9
E-2	1127	1127	1127	1127	1127	1127	1127	1127	1127	1127	1127	1127.4	1127.4	1127.4	1127.4
E-1>4	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006	1006	1005.6	1005.6	1005.6	1005.6
E-1<4	930.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UNOFFICIAL															

Source: Defense Finance and Accounting Service, http//www.dfas.mil/money/milpay/pay/07-00.pdf

Note: Figures rounded to nearest $1 for clarity

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APPENDIX B. INFLATION DATA

Year	Index	% Change
1925	1.000	n/a
1926	0.985	-1.50%
1927	0.965	-2.03%
1928	0.955	-1.04%
1929	0.957	0.21%
1930	0.899	-6.06%
1931	0.814	-9.45%
1932	0.730	-10.32%
1933	0.734	0.55%
1934	0.749	2.04%
1935	0.771	2.94%
1936	0.780	1.17%
1937	0.804	3.08%
1938	0.782	-2.74%
1939	0.778	-0.51%
1940	0.786	1.03%
1941	0.862	9.67%
1942	0.942	9.28%
1943	0.972	3.18%
1944	0.993	2.16%
1945	1.015	2.22%
1946	1.199	18.13%
1947	1.307	9.01%
1948	1.343	2.75%
1949	1.318	-1.86%
1950	1.395	5.84%
1951	1.477	5.88%
1952	1.490	0.88%
1953	1.499	0.60%
1954	1.492	-0.47%
1955	1.497	0.34%
1956	1.540	2.87%
1957	1.587	3.05%
1958	1.615	1.76%
1959	1.639	1.49%
1960	1.663	1.46%
1961	1.674	0.66%
1962	1.695	1.25%
1963	1.723	1.65%
1964	1.743	1.16%
1965	1.777	1.95%

Year	Index	% Change
1966	1.836	3.32%
1967	1.892	3.05%
1968	1.981	4.70%
1969	2.102	6.11%
1970	2.218	5.52%
1971	2.292	3.34%
1972	2.371	3.45%
1973	2.579	8.77%
1974	2.894	12.21%
1975	3.097	7.01%
1976	3.246	4.81%
1977	3.466	6.78%
1978	3.778	9.00%
1979	4.281	13.31%
1980	4.812	12.40%
1981	5.242	8.94%
1982	5.445	3.87%
1983	5.652	3.80%
1984	5.875	3.95%
1985	6.097	3.78%
1986	6.166	1.13%
1987	6.438	4.41%
1988	6.722	4.41%
1989	7.034	4.64%
1990	7.464	6.11%
1991	7.693	3.07%
1992	7.916	2.90%
1993	8.133	2.74%
1994	8.351	2.68%
1995	8.563	2.54%
1996	8.847	3.32%
1997	8.998	1.71%
1998	9.143	1.61%

Source for Raw Index Data:
Stocks, Bonds, Bills and
Inflation - 1999 Yearbook,
Ibbotson Associates,
pp. 256-257

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APPENDIX C. SMALL-COMPANY DATA

Year	Index	% Change
1925	1.000	n/a
1926	1.003	0.30%
1927	1.224	22.03%
1928	1.710	39.71%
1929	0.832	-51.35%
1930	0.515	-38.10%
1931	0.259	-49.71%
1932	0.245	-5.41%
1933	0.594	142.45%
1934	0.738	24.24%
1935	1.035	40.24%
1936	1.705	64.73%
1937	0.716	-58.01%
1938	0.951	32.82%
1939	0.954	0.32%
1940	0.905	-5.14%
1941	0.823	-9.06%
1942	1.190	44.59%
1943	2.242	88.40%
1944	3.446	53.70%
1945	5.983	73.62%
1946	5.287	-11.63%
1947	5.335	0.91%
1948	5.223	-2.10%
1949	6.254	19.74%
1950	8.677	38.74%
1951	9.355	7.81%
1952	9.638	3.03%
1953	9.013	-6.48%
1954	14.473	60.58%
1955	17.431	20.44%
1956	18.177	4.28%
1957	15.529	-14.57%
1958	25.605	64.89%
1959	29.804	16.40%
1960	28.823	-3.29%
1961	38.072	32.09%
1962	33.540	-11.90%
1963	41.444	23.57%
1964	51.193	23.52%
1965	72.567	41.75%

Year	Index	% Change
1966	67.479	-7.01%
1967	123.870	83.57%
1968	168.429	35.97%
1969	126.233	-25.05%
1970	104.226	-17.43%
1971	121.423	16.50%
1972	126.807	4.43%
1973	87.618	-30.90%
1974	70.142	-19.95%
1975	107.189	52.82%
1976	168.691	57.38%
1977	211.500	25.38%
1978	261.120	23.46%
1979	374.614	43.46%
1980	523.992	39.88%
1981	596.717	13.88%
1982	763.829	28.01%
1983	1066.828	39.67%
1984	995.680	-6.67%
1985	1241.234	24.66%
1986	1326.275	6.85%
1987	1202.966	-9.30%
1988	1478.135	22.87%
1989	1628.590	10.18%
1990	1277.449	-21.56%
1991	1847.629	44.63%
1992	2279.039	23.35%
1993	2757.147	20.98%
1994	2842.773	3.11%
1995	3822.398	34.46%
1996	4495.993	17.62%
1997	5519.969	22.78%
1998	5116.648	-7.31%

Source for Raw Index Data:
Stocks, Bonds, Bills and
Inflation - 1999 Yearbook,
Ibbotson Associates, pp. 242-243

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APPENDIX D. LARGE-COMPANY DATA

Year	Index	% Change
1925	1.000	n/a
1926	1.116	11.60%
1927	1.535	37.54%
1928	2.204	43.58%
1929	2.018	-8.44%
1930	1.516	-24.88%
1931	0.859	-43.34%
1932	0.789	-8.15%
1933	1.214	53.87%
1934	1.197	-1.40%
1935	1.767	47.62%
1936	2.367	33.96%
1937	1.538	-35.02%
1938	2.016	31.08%
1939	2.008	-0.40%
1940	1.812	-9.76%
1941	1.602	-11.59%
1942	1.927	20.29%
1943	2.427	25.95%
1944	2.906	19.74%
1945	3.965	36.44%
1946	3.645	-8.07%
1947	3.853	5.71%
1948	4.065	5.50%
1949	4.829	18.79%
1950	6.360	31.70%
1951	7.888	24.03%
1952	9.336	18.36%
1953	9.244	-0.99%
1954	14.108	52.62%
1955	18.561	31.56%
1956	19.778	6.56%
1957	17.646	-10.78%
1958	25.298	43.36%
1959	28.322	11.95%
1960	28.455	0.47%
1961	36.106	26.89%
1962	32.954	-8.73%
1963	40.469	22.80%
1964	47.139	16.48%
1965	53.008	12.45%
1966	47.674	-10.06%
1967	59.104	23.98%
1968	65.642	11.06%
1969	60.059	-8.51%
1970	62.465	4.01%
1971	71.406	14.31%
1972	84.956	18.98%
1973	72.500	-14.66%
1974	53.311	-26.47%
1975	73.144	37.20%
1976	90.584	23.84%
1977	84.077	-7.18%
1978	89.592	6.56%
1979	106.113	18.44%
1980	140.514	32.42%
1981	133.616	-4.91%
1982	162.223	21.41%
1983	198.745	22.51%
1984	211.199	6.27%
1985	279.117	32.16%
1986	330.671	18.47%
1987	347.967	5.23%
1988	406.458	16.81%
1989	534.455	31.49%
1990	517.499	-3.17%
1991	675.592	30.55%
1992	727.412	7.67%
1993	800.078	9.99%
1994	810.538	1.31%
1995	1113.918	37.43%
1996	1370.946	23.07%
1997	1828.326	33.36%
1998	2350.892	28.58%

Source for Raw Index Data: Stocks, Bonds, Bills and Inflation - 1999 Yearbook, Ibbotson Associates, pp. 238-239

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APPENDIX E. INTERMEDIATE-TERM U.S. GOVERNMENT BOND DATA

Year	Index	% Change
1925	1.000	n/a
1926	1.054	5.40%
1927	1.101	4.46%
1928	1.112	1.00%
1929	1.178	5.94%
1930	1.258	6.79%
1931	1.228	-2.38%
1932	1.337	8.88%
1933	1.361	1.80%
1934	1.483	8.96%
1935	1.587	7.01%
1936	1.636	3.09%
1937	1.661	1.53%
1938	1.765	6.26%
1939	1.845	4.53%
1940	1.899	2.93%
1941	1.909	0.53%
1942	1.946	1.94%
1943	2.000	2.77%
1944	2.036	1.80%
1945	2.082	2.26%
1946	2.102	0.96%
1947	2.122	0.95%
1948	2.161	1.84%
1949	2.211	2.31%
1950	2.227	0.72%
1951	2.235	0.36%
1952	2.271	1.61%
1953	2.345	3.26%
1954	2.407	2.64%
1955	2.392	-0.62%
1956	2.382	-0.42%
1957	2.568	7.81%
1958	2.535	-1.29%
1959	2.525	-0.39%
1960	2.822	11.76%
1961	2.874	1.84%
1962	3.034	5.57%
1963	3.084	1.65%

Year	Index	% Change
1964	3.209	4.05%
1965	3.242	1.03%
1966	3.394	4.69%
1967	3.428	1.00%
1968	3.583	4.52%
1969	3.557	-0.73%
1970	4.156	16.84%
1971	4.519	8.73%
1972	4.752	5.16%
1973	4.971	4.61%
1974	5.254	5.69%
1975	5.665	7.82%
1976	6.394	12.87%
1977	6.484	1.41%
1978	6.710	3.49%
1979	6.985	4.10%
1980	7.258	3.91%
1981	7.944	9.45%
1982	10.256	29.10%
1983	11.015	7.40%
1984	12.560	14.03%
1985	15.113	20.33%
1986	17.401	15.14%
1987	17.906	2.90%
1988	18.999	6.10%
1989	21.524	13.29%
1990	23.618	9.73%
1991	27.270	15.46%
1992	29.230	7.19%
1993	32.516	11.24%
1994	30.843	-5.15%
1995	36.025	16.80%
1996	36.782	2.10%
1997	39.864	8.38%
1998	43.933	10.21%

Source for Raw Index Data: Stocks, Bonds, Bills and Inflation - 1999 Yearbook, Ibbotson & Associates, pp. 250-251

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APPENDIX F. U.S. TREASURY BILL DATA

Year	Index	% Change
1925	1.000	n/a
1926	1.033	3.30%
1927	1.065	3.10%
1928	1.103	3.57%
1929	1.155	4.71%
1930	1.183	2.42%
1931	1.196	1.10%
1932	1.207	0.92%
1933	1.211	0.33%
1934	1.213	0.17%
1935	1.215	0.16%
1936	1.217	0.16%
1937	1.221	0.33%
1938	1.221	0.00%
1939	1.221	0.00%
1940	1.221	0.00%
1941	1.222	0.08%
1942	1.225	0.25%
1943	1.229	0.33%
1944	1.233	0.33%
1945	1.237	0.32%
1946	1.242	0.40%
1947	1.248	0.48%
1948	1.258	0.80%
1949	1.272	1.11%
1950	1.287	1.18%
1951	1.306	1.48%
1952	1.328	1.68%
1953	1.352	1.81%
1954	1.364	0.89%
1955	1.385	1.54%
1956	1.419	2.45%
1957	1.464	3.17%
1958	1.486	1.50%
1959	1.530	2.96%
1960	1.571	2.68%
1961	1.604	2.10%
1962	1.648	2.74%
1963	1.700	3.16%
1964	1.760	3.53%

Year	Index	% Change
1965	1.829	3.92%
1966	1.906	4.21%
1967	1.997	4.77%
1968	2.101	5.21%
1969	2.239	6.57%
1970	2.385	6.52%
1971	2.490	4.40%
1972	2.585	3.82%
1973	2.764	6.92%
1974	2.986	8.03%
1975	3.159	5.79%
1976	3.319	5.06%
1977	3.349	0.90%
1978	3.740	11.68%
1979	4.128	10.37%
1980	4.592	11.24%
1981	5.267	14.70%
1982	5.822	10.54%
1983	6.335	8.81%
1984	6.959	9.85%
1985	7.496	7.72%
1986	7.958	6.16%
1987	8.393	5.47%
1988	8.926	6.35%
1989	9.673	8.37%
1990	10.429	7.82%
1991	11.012	5.59%
1992	11.398	3.51%
1993	11.728	2.90%
1994	12.186	3.91%
1995	12.868	5.60%
1996	13.538	5.21%
1997	14.250	5.26%
1998	14.942	4.86%

Source for Raw Index Data:
Stocks, Bonds, Bills and
Inflation - 1999 Yearbook,
Ibbotson Associates, pp. 254-255

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APPENDIX G. SMALL-COMPANY STOCK RETURN MOVING AVERAGES

	Holding Periods			
	1yr	5year	10year	20year
Max	142.45%	53.25%	31.73%	27.47%
Min	-58.01%	-20.97%	8.19%	11.86%

Year	5year	10year	20year
1930	-5.48%		
1931	-15.48%		
1932	-20.97%		
1933	-0.42%		
1934	14.70%		
1935	30.36%	12.44%	
1936	53.25%	18.88%	
1937	42.73%	10.88%	
1938	20.81%	10.19%	
1939	16.02%	15.36%	
1940	6.95%	18.66%	
1941	-7.81%	22.72%	
1942	12.71%	27.72%	
1943	23.82%	22.32%	
1944	34.50%	25.26%	
1945	50.25%	28.60%	20.52%
1946	49.74%	20.96%	19.92%
1947	41.00%	26.85%	18.87%
1948	22.90%	23.36%	16.78%
1949	16.11%	25.30%	20.33%
1950	9.13%	29.69%	24.17%
1951	13.02%	31.38%	27.05%
1952	13.44%	27.22%	27.47%
1953	12.57%	17.73%	20.02%
1954	20.74%	18.42%	21.84%
1955	17.07%	13.10%	20.85%
1956	16.37%	14.69%	17.83%
1957	12.85%	13.15%	20.00%
1958	27.12%	19.85%	21.60%
1959	18.29%	19.51%	22.41%
1960	13.54%	15.31%	22.50%
1961	19.10%	17.74%	24.56%
1962	19.64%	16.24%	21.73%
1963	11.37%	19.25%	18.49%
1964	12.80%	15.54%	16.98%
1965	21.81%	17.67%	15.39%

Year	5year	10year	20year
1966	13.99%	16.54%	15.62%
1967	33.08%	26.36%	19.75%
1968	35.56%	23.47%	21.66%
1969	25.85%	19.32%	19.42%
1970	14.01%	17.91%	16.61%
1971	18.71%	16.35%	17.04%
1972	2.88%	17.98%	17.11%
1973	-10.49%	12.53%	15.89%
1974	-9.47%	8.19%	11.86%
1975	4.58%	9.29%	13.48%
1976	12.76%	15.73%	16.14%
1977	16.94%	9.91%	18.14%
1978	27.82%	8.66%	16.06%
1979	40.50%	15.51%	17.42%
1980	37.91%	21.25%	19.58%
1981	29.21%	20.98%	18.67%
1982	29.74%	23.34%	20.66%
1983	32.98%	30.40%	21.47%
1984	22.95%	31.73%	19.96%
1985	19.91%	28.91%	19.10%
1986	18.50%	23.86%	19.80%
1987	11.04%	20.39%	15.15%
1988	7.68%	20.33%	14.50%
1989	11.05%	17.00%	16.26%
1990	1.81%	10.86%	16.05%
1991	9.37%	13.93%	17.46%
1992	15.90%	13.47%	18.40%
1993	15.52%	11.60%	21.00%
1994	14.10%	12.58%	22.15%
1995	25.31%	13.56%	21.23%
1996	19.90%	14.63%	19.25%
1997	19.79%	17.84%	19.12%
1998	14.13%	14.82%	17.58%

APPENDIX H. LARGE-COMPANY STOCK RETURN MOVING AVERAGES

	Holding Periods			
	1yr	5year	10year	20year
Max	53.87%	25.18%	21.52%	18.00%
Min	-43.34%	-8.24%	2.51%	6.45%

Year	5year	10year	20year
1930	11.88%		
1931	0.89%		
1932	-8.24%		
1933	-6.19%		
1934	-4.78%		
1935	9.72%	10.80%	
1936	25.18%	13.04%	
1937	19.80%	5.78%	
1938	15.25%	4.53%	
1939	15.45%	5.33%	
1940	3.97%	6.85%	
1941	-5.14%	10.02%	
1942	5.92%	12.86%	
1943	4.90%	10.07%	
1944	8.92%	12.19%	
1945	18.16%	11.07%	10.93%
1946	18.87%	6.87%	9.95%
1947	15.95%	10.94%	8.36%
1948	11.86%	8.38%	6.45%
1949	11.67%	10.30%	7.82%
1950	10.73%	14.45%	10.65%
1951	17.15%	18.01%	14.01%
1952	19.68%	17.81%	15.34%
1953	18.38%	15.12%	12.60%
1954	25.14%	18.41%	15.30%
1955	25.12%	17.92%	14.49%
1956	21.62%	19.38%	13.12%
1957	15.79%	17.74%	14.34%
1958	24.66%	21.52%	14.95%
1959	16.53%	20.84%	15.57%
1960	10.31%	17.71%	16.08%
1961	14.38%	18.00%	18.00%
1962	14.79%	15.29%	16.55%
1963	10.68%	17.67%	16.40%
1964	11.58%	14.06%	16.23%
1965	13.98%	12.15%	15.03%

Year	5year	10year	20year
1966	6.59%	10.48%	14.93%
1967	13.13%	13.96%	15.85%
1968	10.78%	10.73%	16.13%
1969	5.78%	8.68%	14.76%
1970	4.10%	9.04%	13.38%
1971	8.97%	7.78%	12.89%
1972	7.97%	10.55%	12.92%
1973	2.83%	6.80%	12.24%
1974	-0.77%	2.51%	8.28%
1975	5.87%	4.98%	8.56%
1976	7.78%	8.37%	9.43%
1977	2.55%	5.26%	9.61%
1978	6.79%	4.81%	7.77%
1979	15.77%	7.50%	8.09%
1980	14.82%	10.34%	9.69%
1981	9.07%	8.42%	8.10%
1982	14.78%	8.67%	9.61%
1983	17.97%	12.38%	9.59%
1984	15.54%	15.66%	9.08%
1985	15.49%	15.15%	10.07%
1986	20.16%	14.61%	11.49%
1987	16.93%	15.86%	10.56%
1988	15.79%	16.88%	10.84%
1989	20.83%	18.19%	12.84%
1990	13.77%	14.63%	12.49%
1991	16.18%	18.17%	13.30%
1992	16.67%	16.80%	12.73%
1993	15.31%	15.55%	13.96%
1994	9.27%	15.05%	15.35%
1995	17.39%	15.58%	15.36%
1996	15.89%	16.04%	15.33%
1997	21.03%	18.85%	17.35%
1998	24.75%	20.03%	18.45%

APPENDIX I. INTERMEDIATE-TERM GOVERNMENT BOND MOVING AVERAGES

	Holding Periods			
	1yr	5year	10year	20year
Max	29.10%	17.20%	13.35%	10.03%
Min	-5.15%	1.02%	1.27%	1.60%

Year	5year	10year	20year
1930	4.72%		
1931	3.16%		
1932	4.04%		
1933	4.20%		
1934	4.81%		
1935	4.85%	4.78%	
1936	5.95%	4.55%	
1937	4.48%	4.26%	
1938	5.37%	4.79%	
1939	4.48%	4.65%	
1940	3.67%	4.26%	
1941	3.16%	4.55%	
1942	3.24%	3.86%	
1943	2.54%	3.96%	
1944	1.99%	3.24%	
1945	1.86%	2.76%	3.77%
1946	1.95%	2.55%	3.55%
1947	1.75%	2.49%	3.38%
1948	1.56%	2.05%	3.42%
1949	1.66%	1.83%	3.24%
1950	1.36%	1.61%	2.93%
1951	1.24%	1.59%	3.07%
1952	1.37%	1.56%	2.71%
1953	1.65%	1.61%	2.78%
1954	1.72%	1.69%	2.47%
1955	1.45%	1.40%	2.08%
1956	1.29%	1.27%	1.91%
1957	2.53%	1.95%	2.22%
1958	1.63%	1.64%	1.85%
1959	1.02%	1.37%	1.60%
1960	3.49%	2.47%	2.04%
1961	3.95%	2.62%	2.11%
1962	3.50%	3.02%	2.29%
1963	4.09%	2.86%	2.23%
1964	4.97%	3.00%	2.34%

Year	5year	10year	20year
1965	2.83%	3.16%	2.28%
1966	3.40%	3.67%	2.47%
1967	2.48%	2.99%	2.47%
1968	3.06%	3.57%	2.61%
1969	2.10%	3.54%	2.45%
1970	5.27%	4.05%	3.26%
1971	6.07%	4.74%	3.68%
1972	6.91%	4.69%	3.86%
1973	6.92%	4.99%	3.92%
1974	8.21%	5.15%	4.08%
1975	6.40%	5.83%	4.50%
1976	7.23%	6.65%	5.16%
1977	6.48%	6.69%	4.84%
1978	6.26%	6.59%	5.08%
1979	5.94%	7.07%	5.31%
1980	5.15%	5.78%	4.91%
1981	4.47%	5.85%	5.29%
1982	10.01%	8.24%	6.47%
1983	10.79%	8.52%	6.76%
1984	12.78%	9.36%	7.26%
1985	16.06%	10.61%	8.22%
1986	17.20%	10.83%	8.74%
1987	11.96%	10.98%	8.84%
1988	11.70%	11.25%	8.92%
1989	11.55%	12.17%	9.62%
1990	9.43%	12.75%	9.26%
1991	9.50%	13.35%	9.60%
1992	10.35%	11.16%	9.70%
1993	11.38%	11.54%	10.03%
1994	7.70%	9.62%	9.49%
1995	9.11%	9.27%	9.94%
1996	6.44%	7.97%	9.40%
1997	6.68%	8.52%	9.75%
1998	6.47%	8.93%	10.09%

APPENDIX J. U.S. TREASURY BILL MOVING AVERAGES

	Holding Periods			
	1yr	5year	10year	20year
Max	14.70%	11.71%	9.65%	7.76%
Min	0.00%	0.07%	0.15%	0.42%

Year	5year	10year	20year
1930	3.42%		
1931	2.98%		
1932	2.55%		
1933	1.90%		
1934	0.99%		
1935	0.54%	1.98%	
1936	0.35%	1.66%	
1937	0.23%	1.39%	
1938	0.16%	1.03%	
1939	0.13%	0.56%	
1940	0.10%	0.32%	
1941	0.08%	0.22%	
1942	0.07%	0.15%	
1943	0.13%	0.15%	
1944	0.20%	0.16%	
1945	0.26%	0.18%	1.08%
1946	0.33%	0.20%	0.93%
1947	0.37%	0.22%	0.80%
1948	0.47%	0.30%	0.67%
1949	0.63%	0.41%	0.49%
1950	0.80%	0.53%	0.42%
1951	1.01%	0.67%	0.44%
1952	1.25%	0.81%	0.48%
1953	1.45%	0.96%	0.55%
1954	1.41%	1.02%	0.59%
1955	1.48%	1.14%	0.66%
1956	1.67%	1.34%	0.77%
1957	1.97%	1.61%	0.92%
1958	1.91%	1.68%	0.99%
1959	2.33%	1.87%	1.14%
1960	2.55%	2.02%	1.27%
1961	2.48%	2.08%	1.37%
1962	2.40%	2.18%	1.50%
1963	2.73%	2.32%	1.64%
1964	2.84%	2.58%	1.80%

Year	5year	10year	20year
1965	3.09%	2.82%	1.98%
1966	3.51%	3.00%	2.17%
1967	3.92%	3.16%	2.38%
1968	4.33%	3.53%	2.60%
1969	4.94%	3.89%	2.88%
1970	5.46%	4.27%	3.14%
1971	5.49%	4.50%	3.29%
1972	5.30%	4.61%	3.40%
1973	5.65%	4.99%	3.65%
1974	5.94%	5.44%	4.01%
1975	5.79%	5.62%	4.22%
1976	5.93%	5.71%	4.35%
1977	5.34%	5.32%	4.24%
1978	6.29%	5.97%	4.75%
1979	6.76%	6.35%	5.12%
1980	7.85%	6.82%	5.55%
1981	9.78%	7.85%	6.18%
1982	11.71%	8.52%	6.57%
1983	11.13%	8.71%	6.85%
1984	11.03%	8.90%	7.17%
1985	10.32%	9.09%	7.36%
1986	8.62%	9.20%	7.45%
1987	7.60%	9.65%	7.49%
1988	7.11%	9.12%	7.55%
1989	6.81%	8.92%	7.64%
1990	6.83%	8.58%	7.70%
1991	6.72%	7.67%	7.76%
1992	6.33%	6.96%	7.74%
1993	5.64%	6.37%	7.54%
1994	4.74%	5.78%	7.34%
1995	4.30%	5.57%	7.33%
1996	4.22%	5.47%	7.33%
1997	4.57%	5.45%	7.55%
1998	4.96%	5.30%	7.21%

APPENDIX K. CORRELATION ANALYSIS OF HISTORICAL TIME SERIES DATA

```
MTB > INFO
```

Information on the Worksheet

```
Column  Count  Name
C1         73  Year
C2         73  Inflation
C3         73  Small-company
C4         73  Large-company
C5         73  Bonds
C6         73  Bills
```

```
MTB > corr c2-c6
```

Correlations (Pearson)

	Inflation	Small-company	Large-company	Bonds
Small-company	0.047 0.692			
Large-company	-0.028 0.811	**0.793** 0.000		
Bonds	0.009 0.942	-0.034 0.778	0.115 0.332	
Bills	**0.404** 0.000	-0.088 0.460	-0.010 0.935	**0.485** 0.000

```
Cell Contents: Correlation
               P-Value
```

MTB > ACF C2

Autocorrelation Function

ACF of Inflation

```
            -1.0 -0.8 -0.6 -0.4 -0.2  0.0  0.2  0.4  0.6  0.8
              +----+----+----+----+----+----+----+----+----+----
  1    0.642                           XXXXXXXXXXXXXXXXX
  2    0.312                           XXXXXXXXX
  3    0.192                           XXXXXX
  4    0.382                           XXXXXXXXXXX
  5    0.412                           XXXXXXXXXXX
  6    0.253                           XXXXXXX
  7    0.093                           XXX
  8    0.011                           X
  9    0.033                           XX
 10   -0.011                           X
 11   -0.036                          XX
 12   -0.074                         XXX
 13   -0.100                        XXXX
 14   -0.236                     XXXXXXX
 15   -0.279                    XXXXXXXX
 16   -0.212                      XXXXXX
 17   -0.106                        XXXX
 18   -0.140                       XXXXX
```

```
MTB > PACF C2
```

Partial Autocorrelation Function
Note: (Items in Bold have been evaluated as statistically significant)

```
PACF of Inflation

          -1.0 -0.8 -0.6 -0.4 -0.2  0.0  0.2  0.4  0.6  0.8
            +----+----+----+----+----+----+----+----+----+----
  1   0.642                          XXXXXXXXXXXXXXXXX
  2  -0.169                      XXXXX
  3   0.116                          XXXX
  4   0.427                          XXXXXXXXXXXX
  5  -0.094                        XXX
  6  -0.103                       XXXX
  7   0.057                          XX
  8  -0.206                     XXXXXX
  9  -0.028                         XX
 10  -0.080                        XXX
 11   0.004                          X
 12   0.017                          X
 13  -0.068                        XXX
 14  -0.241                    XXXXXXX
 15   0.048                          XX
 16   0.035                          XX
 17  -0.021                         XX
 18  -0.011                          X
```

```
MTB > ACF C3
```

Autocorrelation Function

```
ACF of Small-company

            -1.0 -0.8 -0.6 -0.4 -0.2  0.0  0.2  0.4  0.6  0.8
              +----+----+----+----+----+----+----+----+----+----
  1   0.086                           XXX
  2  -0.084                         XXX
  3  -0.065                         XXX
  4  -0.226                     XXXXXXX
  5  -0.096                         XXX
  6  -0.158                       XXXXX
  7  -0.070                         XXX
  8  -0.007                           X
  9   0.158                           XXXXX
 10   0.109                           XXXX
 11   0.076                           XXX
 12  -0.002                           X
 13  -0.120                        XXXX
 14  -0.133                        XXXX
 15  -0.054                          XX
 16   0.076                           XXX
 17   0.062                           XXX
 18   0.022                           XX
```

MTB > PACF C3

Partial Autocorrelation Function

PACF of Small-company

```
          -1.0 -0.8 -0.6 -0.4 -0.2  0.0  0.2  0.4  0.6  0.8
            +----+----+----+----+----+----+----+----+----+----
  1   0.086                          XXX
  2  -0.092                        XXX
  3  -0.050                         XX
  4  -0.228                    XXXXXXX
  5  -0.073                        XXX
  6  -0.207                     XXXXXX
  7  -0.103                       XXXX
  8  -0.122                       XXXX
  9   0.086                          XXX
 10  -0.024                         XX
 11   0.038                          XX
 12  -0.058                         XX
 13  -0.084                        XXX
 14  -0.137                       XXXX
 15  -0.017                          X
 16   0.064                          XXX
 17   0.036                          XX
 18  -0.043                         XX
```

```
MTB > ACF C4
```

Autocorrelation Function

```
ACF of Large-company

            -1.0 -0.8 -0.6 -0.4 -0.2  0.0  0.2  0.4  0.6  0.8
              +----+----+----+----+----+----+----+----+----+---+
  1   0.007                          X
  2  -0.160                      XXXXX
  3  -0.012                          X
  4  -0.119                       XXXX
  5  -0.037                         XX
  6  -0.021                         XX
  7   0.104                          XXXX
  8   0.009                          X
  9   0.161                          XXXXX
 10   0.056                          XX
 11  -0.023                         XX
 12  -0.047                         XX
 13  -0.095                        XXX
 14  -0.138                       XXXX
 15  -0.068                        XXX
 16   0.122                          XXXX
 17   0.058                          XX
 18  -0.063                        XXX
```

```
MTB > PACF C4
```

Partial Autocorrelation Function

```
PACF of Large-company

            -1.0 -0.8 -0.6 -0.4 -0.2  0.0  0.2  0.4  0.6  0.8
              +----+----+----+----+----+----+----+----+----+---
  1   0.007                            X
  2  -0.160                        XXXXX
  3  -0.010                            X
  4  -0.148                        XXXXX
  5  -0.041                           XX
  6  -0.070                          XXX
  7   0.091                            XXX
  8  -0.028                           XX
  9   0.199                            XXXXXX
 10   0.044                            XX
 11   0.078                            XXX
 12  -0.028                           XX
 13  -0.029                           XX
 14  -0.165                        XXXXX
 15  -0.084                          XXX
 16   0.012                            X
 17   0.004                            X
 18  -0.124                         XXXX
```

```
MTB > ACF C5
```

Autocorrelation Function

```
ACF of Bonds

          -1.0 -0.8 -0.6 -0.4 -0.2  0.0  0.2  0.4  0.6  0.8
            +----+----+----+----+----+----+----+----+----+----
  1   0.183                          XXXXXX
  2   0.304                          XXXXXXXXX
  3   0.264                          XXXXXXXX
  4   0.295                          XXXXXXXX
  5   0.138                          XXXX
  6   0.320                          XXXXXXXXX
  7   0.204                          XXXXXX
  8   0.170                          XXXXX
  9   0.223                          XXXXXXX
 10   0.232                          XXXXXXX
 11   0.200                          XXXXXX
 12   0.056                          XX
 13   0.188                          XXXXXX
 14   0.135                          XXXX
 15   0.123                          XXXX
 16   0.107                          XXXX
 17  -0.039                         XX
 18  -0.048                         XX
```

```
MTB > PACF C5
```

Partial Autocorrelation Function

```
PACF of Bonds

            -1.0 -0.8 -0.6 -0.4 -0.2  0.0  0.2  0.4  0.6  0.8
              +----+----+----+----+----+----+----+----+----+----
  1   0.183                            XXXXXX
  2   0.280                            XXXXXXXX
  3   0.194                            XXXXXX
  4   0.189                            XXXXXX
  5  -0.021                           XX
  6   0.181                            XXXXXX
  7   0.070                            XXX
  8  -0.014                            X
  9   0.076                            XXX
 10   0.068                            XXX
 11   0.072                            XXX
 12  -0.157                        XXXXX
 13   0.015                            X
 14   0.038                            XX
 15  -0.005                            X
 16  -0.011                            X
 17  -0.243                      XXXXXXX
 18  -0.135                         XXXX
```

```
MTB > ACF C6
```

Autocorrelation Function

```
ACF of Bills

          -1.0 -0.8 -0.6 -0.4 -0.2  0.0  0.2  0.4  0.6  0.8
            +----+----+----+----+----+----+----+----+----+----
  1   0.851                          XXXXXXXXXXXXXXXXXXXXXX
  2   0.766                          XXXXXXXXXXXXXXXXXXXX
  3   0.714                          XXXXXXXXXXXXXXXXXXX
  4   0.655                          XXXXXXXXXXXXXXXXX
  5   0.662                          XXXXXXXXXXXXXXXXXX
  6   0.627                          XXXXXXXXXXXXXXXXX
  7   0.570                          XXXXXXXXXXXXXXX
  8   0.548                          XXXXXXXXXXXXXXX
  9   0.511                          XXXXXXXXXXXXXX
 10   0.479                          XXXXXXXXXXXXX
 11   0.437                          XXXXXXXXXXXX
 12   0.355                          XXXXXXXXXX
 13   0.302                          XXXXXXXXX
 14   0.288                          XXXXXXXX
 15   0.269                          XXXXXXXX
 16   0.241                          XXXXXXX
 17   0.177                          XXXXX
 18   0.095                          XXX
```

```
MTB > PACF C6
```

Partial Autocorrelation Function
Note: (Items in Bold have been evaluated as statistically significant)

```
PACF of Bills

            -1.0 -0.8 -0.6 -0.4 -0.2  0.0  0.2  0.4  0.6  0.8
              +----+----+----+----+----+----+----+----+----+----
  1   0.851                           XXXXXXXXXXXXXXXXXXXXXX
  2   0.151                           XXXXX
  3   0.120                           XXXX
  4   0.004                           X
  5   0.234                           XXXXXXX
  6  -0.044                          XX
  7  -0.074                         XXX
  8   0.055                           XX
  9   0.002                           X
 10  -0.032                          XX
 11  -0.080                         XXX
 12  -0.159                       XXXXX
 13  -0.031                          XX
 14   0.082                           XXX
 15   0.020                           XX
 16  -0.057                          XX
```

Summary

Note: (Items in Bold have been evaluated as statistically significant and will be included in the model)

Cross-Correlations (Pearson)

	Inflation	Small-co.	Large-co.	Bonds	Bills
Small-co.	n/a				
Large-co.	n/a	**0.793**			
Bonds	n/a	n/a	n/a		
Bills	**0.404**	n/a	n/a	**0.485**	
Autocorrelation	**0.642**	n/a	n/a	n/a	**0.851**

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APPENDIX L. RETIREMENT PLANNING MODEL

	A	B	C
1			
2		**Instructions:**	
3		1 - Complete Drop-Down Selections and Yellow Shaded Cells Of Sections 1, 2, and 3	
4		2 - Review Outputs At Section 4	
5		3 - Run Monte Carlo Simulation Using Crystal-ball Add-in	
6			
7		**Section (1) Inputs:**	
8		Current Age	33
9		Desired Full Retirement Age	67
10		Retirement Plan (Final Pay, High-3 Pay or REDUX)	REDUX
11		Planned Total Years of Service	22
12		Planned Military Retirement Rank	O-5
13		Anticipated Future Monthly Needs In Today's Dollars	**$5,500**
14		Estimated Monthly Social Security Benefit In Today's Dollars	**$1,100**
15			
16		**Section (2) Pre-Retirement Savings Planning Section:**	
17		Current Retirement Savings	**$10,000**
18		Yearly Savings Going Towards Retirement In Today's Dollars	**$4,000**
19		Anticipated Yearly Percentage Increase in Savings Going Towards Retirement	**2%**
20		**Investment Savings Allocation**	
21		Small-Company Stocks	**50%**
22		Large-Company Stocks	**30%**
23		Bonds	**20%**
24		Money Market	**0%**
25		Total Allocation (Must Equal 100%)	**100%**
26			
27		**Section (3) Retirement Savings Planning Section:**	
28		**Investment Savings Allocation**	
29		Small-Company Stocks	**20%**
30		Large-Company Stocks	**30%**
31		Bonds	**30%**
32		Money Market	**20%**
33		Total Allocation (Must Equal 100%)	**100%**
34			
35		**Section (4) Outputs:**	
36		Retirement Pay Multiplier	**47.0%**
37		Current Monthly Base Pay For Planned Retirement Rank and YOS	**$5,752**
38		Estimated Monthly Military Retirement Benefit In Today's Dollars	**$2,433**
39		**Inflation-Adjusted Data @ 1st Year Of Full Retirement:**	
40		Estimated Monthly Needs	**$15,892**
41		Estimated Monthly Military Retirement Pension	**$7,912**
42		Estimated Monthly Social Security Benefits	**$3,616**
43		**Projections:**	
44		Amount Saved At Retirement	**$ 4,269,268**
45		Years of Retirement Provided	**45**
46		Savings Lasts Until Age	**Unlimited**
47			
48		**Input/Output Worksheet**	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Age	Beginning Balance	Inflation	Small Co. Investment Return	Large Co. Investment Return	Bond Investment Return	Money-Market Investment Return	Annual Earnings	Annual Contribution	Ending Balance	Inflation Adjusted Monthly Retirement Need	REDUX	REDUX Adjustment at 62 and Beyond	Final Pay or High-3	Inflation Adjusted Monthly Military Retirement Income	Inflation Adjusted Monthly Social Security Retirement Income
2	33	$10,000	3.17%	17.38%	13.17%	5.47%	3.83%	$1,374	$4,000	$15,374	$5,500	$2,433		$2,847	$2,433	$1,100
3	34	$15,374	3.17%	17.38%	13.17%	5.47%	3.83%	$2,112	$4,209	$21,694	$5,674	$2,486		$2,937	$2,486	$1,135
4	35	$21,694	3.17%	17.38%	13.17%	5.47%	3.83%	$2,980	$4,430	$29,104	$5,854	$2,540		$3,031	$2,540	$1,171
5	36	$29,104	3.17%	17.38%	13.17%	5.47%	3.83%	$3,997	$4,661	$37,763	$6,040	$2,595		$3,127	$2,595	$1,208
6	37	$37,763	3.17%	17.38%	13.17%	5.47%	3.83%	$5,187	$4,905	$47,855	$6,231	$2,651		$3,226	$2,651	$1,246
7	38	$47,855	3.17%	17.38%	13.17%	5.47%	3.83%	$6,573	$5,162	$59,590	$6,429	$2,709		$3,328	$2,709	$1,286
8	39	$59,590	3.17%	17.38%	13.17%	5.47%	3.83%	$8,185	$5,432	$73,207	$6,633	$2,768		$3,434	$2,768	$1,327
9	40	$73,207	3.17%	17.38%	13.17%	5.47%	3.83%	$10,055	$5,717	$88,978	$6,843	$2,828		$3,542	$2,828	$1,369
10	41	$88,978	3.17%	17.38%	13.17%	5.47%	3.83%	$12,221	$6,016	$107,215	$7,060	$2,889		$3,655	$2,889	$1,412
11	42	$107,215	3.17%	17.38%	13.17%	5.47%	3.83%	$14,726	$6,331	$128,271	$7,284	$2,952		$3,770	$2,952	$1,457
12	43	$128,271	3.17%	17.38%	13.17%	5.47%	3.83%	$17,618	$6,662	$152,551	$7,514	$3,016		$3,890	$3,016	$1,503
13	44	$152,551	3.17%	17.38%	13.17%	5.47%	3.83%	$20,953	$7,011	$180,515	$7,753	$3,081		$4,013	$3,081	$1,551
14	45	$180,515	3.17%	17.38%	13.17%	5.47%	3.83%	$24,794	$7,377	$212,686	$7,998	$3,148		$4,141	$3,148	$1,600
15	46	$212,686	3.17%	17.38%	13.17%	5.47%	3.83%	$29,212	$7,763	$249,662	$8,252	$3,216		$4,272	$3,216	$1,650
16	47	$249,662	3.17%	17.38%	13.17%	5.47%	3.83%	$34,291	$8,170	$292,123	$8,514	$3,286		$4,407	$3,286	$1,703
17	48	$292,123	3.17%	17.38%	13.17%	5.47%	3.83%	$40,123	$8,597	$340,843	$8,783	$3,357		$4,547	$3,357	$1,757
18	49	$340,843	3.17%	17.38%	13.17%	5.47%	3.83%	$46,815	$9,047	$396,705	$9,062	$3,430		$4,691	$3,430	$1,812
19	50	$396,705	3.17%	17.38%	13.17%	5.47%	3.83%	$54,487	$9,521	$460,713	$9,349	$3,505		$4,840	$3,505	$1,870
20	51	$460,713	3.17%	17.38%	13.17%	5.47%	3.83%	$63,279	$10,019	$534,011	$9,645	$3,581		$4,993	$3,581	$1,929
21	52	$534,011	3.17%	17.38%	13.17%	5.47%	3.83%	$73,346	$10,543	$617,901	$9,951	$3,658		$5,151	$3,658	$1,990
22	53	$617,901	3.17%	17.38%	13.17%	5.47%	3.83%	$84,869	$11,095	$713,865	$10,267	$3,738		$5,315	$3,738	$2,053
23	54	$713,865	3.17%	17.38%	13.17%	5.47%	3.83%	$98,049	$11,676	$823,590	$10,592	$3,819		$5,483	$3,819	$2,118
24	55	$823,590	3.17%	17.38%	13.17%	5.47%	3.83%	$113,120	$12,287	$948,997	$10,928	$3,902		$5,657	$3,902	$2,186
25	56	$948,997	3.17%	17.38%	13.17%	5.47%	3.83%	$130,345	$12,930	$1,092,271	$11,274	$3,986		$5,836	$3,986	$2,255
26	57	$1,092,271	3.17%	17.38%	13.17%	5.47%	3.83%	$150,023	$13,607	$1,255,901	$11,632	$4,073		$6,021	$4,073	$2,326
27	58	$1,255,901	3.17%	17.38%	13.17%	5.47%	3.83%	$172,498	$14,319	$1,442,718	$12,000	$4,161		$6,212	$4,161	$2,400
28	59	$1,442,718	3.17%	17.38%	13.17%	5.47%	3.83%	$198,157	$15,068	$1,655,943	$12,381	$4,252		$6,409	$4,252	$2,476
29	60	$1,655,943	3.17%	17.38%	13.17%	5.47%	3.83%	$227,444	$15,856	$1,899,244	$12,773	$4,344		$6,612	$4,344	$2,555
30	61	$1,899,244	3.17%	17.38%	13.17%	5.47%	3.83%	$260,861	$16,686	$2,176,791	$13,178	$4,438		$6,822	$4,438	$2,636
31	62	$2,176,791	3.17%	17.38%	13.17%	5.47%	3.83%	$298,982	$17,560	$2,493,333	$13,596	$4,535	$7,038	$7,038	$7,038	$2,719
32	63	$2,493,333	3.17%	17.38%	13.17%	5.47%	3.83%	$342,459	$18,479	$2,854,271	$14,027		$7,191	$7,261	$7,191	$2,805
33	64	$2,854,271	3.17%	17.38%	13.17%	5.47%	3.83%	$392,034	$19,446	$3,265,751	$14,472		$7,347	$7,492	$7,347	$2,894
34	65	$3,265,751	3.17%	17.38%	13.17%	5.47%	3.83%	$448,551	$20,463	$3,734,765	$14,930		$7,506	$7,729	$7,506	$2,986
35	66	$3,734,765	3.17%	17.38%	13.17%	5.47%	3.83%	$512,970	$21,534	$4,269,269	$15,404		$7,669	$7,974	$7,669	$3,081
53																
54																
55	Accumulation Worksheet															

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Age	Beginning Balance	Inflation	Small Co. Investment Return	Large Co. Investment Return	Bond Investment Return	Money-Market Investment Return	Annual Income Requirement	Inflation Adjusted Annual Military Retirement Income	Inflation Adjusted Monthly Social Security Retirement Income	Net Retirement Savings Withdrawal	Annual Earnings	Ending Balance
2	67	$4,269,269	3.17%	17.38%	13.17%	5.47%	3.83%	$190,704	$94,950	$43,394	$52,360	$401,086	$4,617,995
3	68	$4,617,995	3.17%	17.38%	13.17%	5.47%	3.83%	$196,750	$97,010	$44,770	$54,970	$434,785	$4,997,810
4	69	$4,997,810	3.17%	17.38%	13.17%	5.47%	3.83%	$202,987	$99,115	$46,189	$57,682	$471,523	$5,411,651
5	70	$5,411,651	3.17%	17.38%	13.17%	5.47%	3.83%	$209,421	$101,266	$47,653	$60,502	$511,587	$5,862,736
6	71	$5,862,736	3.17%	17.38%	13.17%	5.47%	3.83%	$216,060	$103,464	$49,164	$63,433	$555,294	$6,354,598
7	72	$6,354,598	3.17%	17.38%	13.17%	5.47%	3.83%	$222,909	$105,709	$50,722	$66,478	$602,990	$6,891,110
8	73	$6,891,110	3.17%	17.38%	13.17%	5.47%	3.83%	$229,975	$108,003	$52,330	$69,642	$655,056	$7,476,523
9	74	$7,476,523	3.17%	17.38%	13.17%	5.47%	3.83%	$237,265	$110,346	$53,989	$72,930	$711,909	$8,115,502
10	75	$8,115,502	3.17%	17.38%	13.17%	5.47%	3.83%	$244,787	$112,741	$55,700	$76,345	$774,006	$8,813,162
11	76	$8,813,162	3.17%	17.38%	13.17%	5.47%	3.83%	$252,547	$115,187	$57,466	$79,893	$841,851	$9,575,120
12	77	$9,575,120	3.17%	17.38%	13.17%	5.47%	3.83%	$260,552	$117,687	$59,288	$83,578	$915,995	$10,407,537
13	78	$10,407,537	3.17%	17.38%	13.17%	5.47%	3.83%	$268,812	$120,241	$61,167	$87,404	$997,042	$11,317,176
14	79	$11,317,176	3.17%	17.38%	13.17%	5.47%	3.83%	$277,333	$122,850	$63,106	$91,377	$1,085,658	$12,311,457
15	80	$12,311,457	3.17%	17.38%	13.17%	5.47%	3.83%	$286,125	$125,516	$65,107	$95,502	$1,182,571	$13,398,526
16	81	$13,398,526	3.17%	17.38%	13.17%	5.47%	3.83%	$295,195	$128,239	$67,171	$99,785	$1,288,582	$14,587,323
17	82	$14,587,323	3.17%	17.38%	13.17%	5.47%	3.83%	$304,552	$131,022	$69,300	$104,230	$1,404,568	$15,887,661
18	83	$15,887,661	3.17%	17.38%	13.17%	5.47%	3.83%	$314,207	$133,865	$71,497	$108,845	$1,531,493	$17,310,310
19	84	$17,310,310	3.17%	17.38%	13.17%	5.47%	3.83%	$324,167	$136,770	$73,763	$113,634	$1,670,417	$18,867,093
20	85	$18,867,093	3.17%	17.38%	13.17%	5.47%	3.83%	$334,443	$139,738	$76,101	$118,603	$1,822,501	$20,570,991
21	86	$20,570,991	3.17%	17.38%	13.17%	5.47%	3.83%	$345,045	$142,771	$78,514	$123,761	$1,989,020	$22,436,250
22	87	$22,436,250	3.17%	17.38%	13.17%	5.47%	3.83%	$355,983	$145,869	$81,003	$129,111	$2,171,373	$24,478,512
23	88	$24,478,512	3.17%	17.38%	13.17%	5.47%	3.83%	$367,268	$149,034	$83,571	$134,663	$2,371,100	$26,714,948
24	89	$26,714,948	3.17%	17.38%	13.17%	5.47%	3.83%	$378,910	$152,268	$86,220	$140,422	$2,589,886	$29,164,412
25	90	$29,164,412	3.17%	17.38%	13.17%	5.47%	3.83%	$390,921	$155,572	$88,953	$146,396	$2,829,585	$31,847,601
26	91	$31,847,601	3.17%	17.38%	13.17%	5.47%	3.83%	$403,314	$158,948	$91,773	$152,593	$3,092,231	$34,787,240
27	92	$34,787,240	3.17%	17.38%	13.17%	5.47%	3.83%	$416,099	$162,397	$94,682	$159,019	$3,380,058	$38,008,278
28	93	$38,008,278	3.17%	17.38%	13.17%	5.47%	3.83%	$429,289	$165,921	$97,683	$165,684	$3,695,518	$41,538,112
29	94	$41,538,112	3.17%	17.38%	13.17%	5.47%	3.83%	$442,897	$169,522	$100,780	$172,596	$4,041,303	$45,406,820
30	95	$45,406,820	3.17%	17.38%	13.17%	5.47%	3.83%	$456,937	$173,201	$103,975	$179,762	$4,420,371	$49,647,429
31	96	$49,647,429	3.17%	17.38%	13.17%	5.47%	3.83%	$471,422	$176,959	$107,271	$187,193	$4,835,969	$54,296,205
32	97	$54,296,205	3.17%	17.38%	13.17%	5.47%	3.83%	$486,366	$180,799	$110,671	$194,896	$5,291,660	$59,392,968
33	98	$59,392,968	3.17%	17.38%	13.17%	5.47%	3.83%	$501,784	$184,722	$114,179	$202,882	$5,791,359	$64,981,445
34	99	$64,981,445	3.17%	17.38%	13.17%	5.47%	3.83%	$517,691	$188,731	$117,799	$211,161	$6,339,366	$71,109,650
35	100	$71,109,650	3.17%	17.38%	13.17%	5.47%	3.83%	$534,101	$192,826	$121,533	$219,742	$6,940,399	$77,830,307
36	101	$77,830,307	3.17%	17.38%	13.17%	5.47%	3.83%	$551,032	$197,011	$125,386	$228,636	$7,599,644	$85,201,314
37	102	$85,201,314	3.17%	17.38%	13.17%	5.47%	3.83%	$568,500	$201,286	$129,360	$237,854	$8,322,791	$93,286,251
38	103	$93,286,251	3.17%	17.38%	13.17%	5.47%	3.83%	$586,522	$205,654	$133,461	$247,407	$9,116,091	$102,154,936
39	104	$102,154,936	3.17%	17.38%	13.17%	5.47%	3.83%	$605,114	$210,116	$137,692	$257,306	$9,986,409	$111,884,039
40	105	$111,884,039	3.17%	17.38%	13.17%	5.47%	3.83%	$624,297	$214,676	$142,057	$267,564	$10,941,283	$122,557,758
41	106	$122,557,758	3.17%	17.38%	13.17%	5.47%	3.83%	$644,087	$219,334	$146,560	$278,193	$11,988,990	$134,268,556
42	107	$134,268,556	3.17%	17.38%	13.17%	5.47%	3.83%	$664,504	$224,094	$151,206	$289,205	$13,138,622	$147,117,974
43	108	$147,117,974	3.17%	17.38%	13.17%	5.47%	3.83%	$685,569	$228,957	$155,999	$300,613	$14,400,163	$161,217,523
44	109	$161,217,523	3.17%	17.38%	13.17%	5.47%	3.83%	$707,302	$233,925	$160,944	$312,432	$15,784,575	$176,689,666
45	110	$176,689,666	3.17%	17.38%	13.17%	5.47%	3.83%	$729,723	$239,001	$166,046	$324,676	$17,303,901	$193,668,891
46	111	$193,668,891	3.17%	17.38%	13.17%	5.47%	3.83%	$752,855	$244,188	$171,310	$337,358	$18,971,363	$212,302,896
47	112	$212,302,896	3.17%	17.38%	13.17%	5.47%	3.83%	$776,721	$249,486	$176,740	$350,494	$20,801,484	$232,753,886
48													
49	Withdrawal Worksheet												

	A	B	C	D	E	F
1	Age	Inflation	Small Cap Investment Return	Large Cap Investment Return	Bond Investment Return	Money-Market Investment Return
2	33	3.17%	17.38%	13.17%	5.47%	3.83%
3	34	3.17%	17.38%	13.17%	5.47%	3.83%
4	35	3.17%	17.38%	13.17%	5.47%	3.83%
5	36	3.17%	17.38%	13.17%	5.47%	3.83%
6	37	3.17%	17.38%	13.17%	5.47%	3.83%
7	38	3.17%	17.38%	13.17%	5.47%	3.83%
8	39	3.17%	17.38%	13.17%	5.47%	3.83%
9	40	3.17%	17.38%	13.17%	5.47%	3.83%
10	41	3.17%	17.38%	13.17%	5.47%	3.83%
11	42	3.17%	17.38%	13.17%	5.47%	3.83%
12	43	3.17%	17.38%	13.17%	5.47%	3.83%
13	44	3.17%	17.38%	13.17%	5.47%	3.83%
14	45	3.17%	17.38%	13.17%	5.47%	3.83%
15	46	3.17%	17.38%	13.17%	5.47%	3.83%
16	47	3.17%	17.38%	13.17%	5.47%	3.83%
17	48	3.17%	17.38%	13.17%	5.47%	3.83%
18	49	3.17%	17.38%	13.17%	5.47%	3.83%
19	50	3.17%	17.38%	13.17%	5.47%	3.83%
20	51	3.17%	17.38%	13.17%	5.47%	3.83%
21	52	3.17%	17.38%	13.17%	5.47%	3.83%
22	53	3.17%	17.38%	13.17%	5.47%	3.83%
23	54	3.17%	17.38%	13.17%	5.47%	3.83%
24	55	3.17%	17.38%	13.17%	5.47%	3.83%
25	56	3.17%	17.38%	13.17%	5.47%	3.83%
26	57	3.17%	17.38%	13.17%	5.47%	3.83%
27	58	3.17%	17.38%	13.17%	5.47%	3.83%
28	59	3.17%	17.38%	13.17%	5.47%	3.83%
29	60	3.17%	17.38%	13.17%	5.47%	3.83%
30	61	3.17%	17.38%	13.17%	5.47%	3.83%
31	62	3.17%	17.38%	13.17%	5.47%	3.83%
32	63	3.17%	17.38%	13.17%	5.47%	3.83%
33	64	3.17%	17.38%	13.17%	5.47%	3.83%
34	65	3.17%	17.38%	13.17%	5.47%	3.83%
35	66	3.17%	17.38%	13.17%	5.47%	3.83%
36	67	3.17%	17.38%	13.17%	5.47%	3.83%
37	68	3.17%	17.38%	13.17%	5.47%	3.83%
38	69	3.17%	17.38%	13.17%	5.47%	3.83%
39	70	3.17%	17.38%	13.17%	5.47%	3.83%
40	71	3.17%	17.38%	13.17%	5.47%	3.83%
41	72	3.17%	17.38%	13.17%	5.47%	3.83%
42	73	3.17%	17.38%	13.17%	5.47%	3.83%
43	74	3.17%	17.38%	13.17%	5.47%	3.83%
44	75	3.17%	17.38%	13.17%	5.47%	3.83%
45	76	3.17%	17.38%	13.17%	5.47%	3.83%
46	77	3.17%	17.38%	13.17%	5.47%	3.83%
47	78	3.17%	17.38%	13.17%	5.47%	3.83%
48	79	3.17%	17.38%	13.17%	5.47%	3.83%
49	80	3.17%	17.38%	13.17%	5.47%	3.83%
50	81	3.17%	17.38%	13.17%	5.47%	3.83%
51	82	3.17%	17.38%	13.17%	5.47%	3.83%
52	83	3.17%	17.38%	13.17%	5.47%	3.83%
53	84	3.17%	17.38%	13.17%	5.47%	3.83%
54	85	3.17%	17.38%	13.17%	5.47%	3.83%
55	86	3.17%	17.38%	13.17%	5.47%	3.83%
56	87	3.17%	17.38%	13.17%	5.47%	3.83%
57	88	3.17%	17.38%	13.17%	5.47%	3.83%
58	89	3.17%	17.38%	13.17%	5.47%	3.83%
59	90	3.17%	17.38%	13.17%	5.47%	3.83%
60	91	3.17%	17.38%	13.17%	5.47%	3.83%
61	92	3.17%	17.38%	13.17%	5.47%	3.83%
62	93	3.17%	17.38%	13.17%	5.47%	3.83%
63	94	3.17%	17.38%	13.17%	5.47%	3.83%
64	95	3.17%	17.38%	13.17%	5.47%	3.83%
65	96	3.17%	17.38%	13.17%	5.47%	3.83%
66	97	3.17%	17.38%	13.17%	5.47%	3.83%
67	98	3.17%	17.38%	13.17%	5.47%	3.83%
68	99	3.17%	17.38%	13.17%	5.47%	3.83%
69	100	3.17%	17.38%	13.17%	5.47%	3.83%
70	101	3.17%	17.38%	13.17%	5.47%	3.83%

	A	B	C	D	E	F	G	H	I	J	K	L	M
1			YEARS OF SERVICE										
2	ID	RANK	20	21	22	23	24	25	26	27	28	29	30
3	1	O-10	$10,655	$10,655	$10,708	$10,708	$10,930	$10,930	$11,318	$11,318	$11,318	$11,318	$11,318
4	2	O-9	$9,320	$9,320	$9,454	$9,454	$9,648	$9,648	$9,986	$9,986	$9,986	$9,986	$9,986
5	3	O-8	$8,830	$8,830	$9,048	$9,048	$9,048	$9,048	$9,048	$9,048	$9,048	$9,048	$9,048
6	4	O-7	$7,985	$7,985	$7,985	$7,985	$7,985	$7,985	$8,026	$8,026	$8,026	$8,026	$8,026
7	5	O-6	$6,381	$6,381	$6,549	$6,549	$6,719	$6,719	$7,049	$7,049	$7,049	$7,049	$7,049
8	6	O-5	$5,584	$5,584	$5,752	$5,752	$5,752	$5,752	$5,752	$5,752	$5,752	$5,752	$5,752
9	7	O-4	$4,809	$4,809	$4,809	$4,809	$4,809	$4,809	$4,809	$4,809	$4,809	$4,809	$4,809
10	8	O-3E	$4,139	$4,139	$4,139	$4,139	$4,139	$4,139	$4,139	$4,139	$4,139	$4,139	$4,139
11	9	O-2E	$3,071	$3,071	$3,071	$3,071	$3,071	$3,071	$3,071	$3,071	$3,071	$3,071	$3,071
12	10	O-1	$2,423	$2,423	$2,423	$2,423	$2,423	$2,423	$2,423	$2,423	$2,423	$2,423	$2,423
13	11	O-3E	$4,417	$4,417	$4,417	$4,417	$4,417	$4,417	$4,417	$4,417	$4,417	$4,417	$4,417
14	12	O-2E	$3,556	$3,556	$3,556	$3,556	$3,556	$3,556	$3,556	$3,556	$3,556	$3,556	$3,556
15	13	O-1E	$3,009	$3,009	$3,009	$3,009	$3,009	$3,009	$3,009	$3,009	$3,009	$3,009	$3,009
16	14	W-5	$4,475	$4,475	$4,629	$4,629	$4,783	$4,783	$4,937	$4,937	$4,937	$4,937	$4,937
17	15	W-4	$4,019	$4,019	$4,156	$4,156	$4,290	$4,290	$4,427	$4,427	$4,427	$4,427	$4,427
18	16	W-3	$3,539	$3,539	$3,659	$3,659	$3,780	$3,780	$3,901	$3,901	$3,901	$3,901	$3,901
19	17	W-2	$3,164	$3,164	$3,271	$3,271	$3,378	$3,378	$3,378	$3,378	$3,378	$3,378	$3,378
20	18	W-1	$2,911	$2,911	$2,911	$2,911	$2,911	$2,911	$2,911	$2,911	$2,911	$2,911	$2,911
21	19	E-9	$3,473	$3,473	$3,609	$3,609	$3,744	$3,744	$3,916	$3,916	$3,916	$3,916	$3,916
22	20	E-8	$3,026	$3,026	$3,161	$3,161	$3,296	$3,296	$3,484	$3,484	$3,484	$3,484	$3,484
23	21	E-7	$2,660	$2,660	$2,788	$2,788	$2,926	$2,926	$3,134	$3,134	$3,134	$3,134	$3,134
24	22	E-6	$2,283	$2,283	$2,286	$2,286	$2,286	$2,286	$2,286	$2,286	$2,286	$2,286	$2,286
25	23	E-5	$1,936	$1,936	$1,936	$1,936	$1,936	$1,936	$1,936	$1,936	$1,936	$1,936	$1,936
26	24	E-4	$1,594	$1,594	$1,594	$1,594	$1,594	$1,594	$1,594	$1,594	$1,594	$1,594	$1,594
27	25	E-3	$1,336	$1,336	$1,336	$1,336	$1,336	$1,336	$1,336	$1,336	$1,336	$1,336	$1,336
28	26	E-2	$1,127	$1,127	$1,127	$1,127	$1,127	$1,127	$1,127	$1,127	$1,127	$1,127	$1,127
29	27	E-1	$1,006	$1,006	$1,006	$1,006	$1,006	$1,006	$1,006	$1,006	$1,006	$1,006	$1,006
30													
31	**Pay Table Lookup Worksheet**												

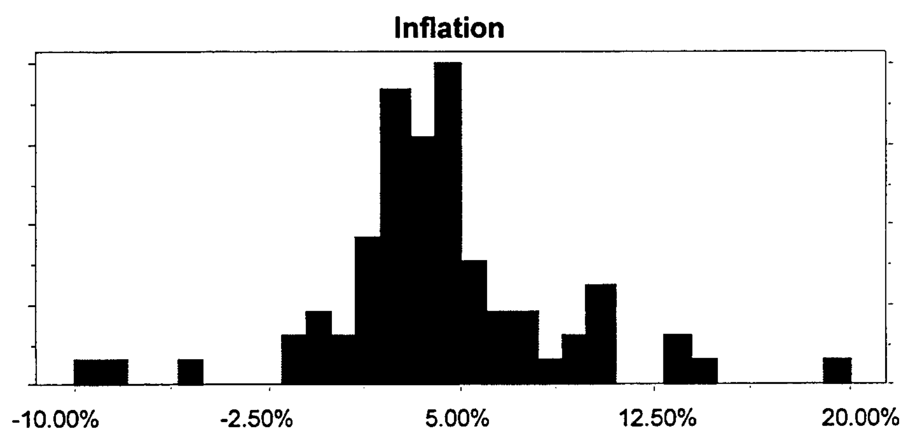
Assumption: Inflation **Cell: B2-B79**

Custom distribution with parameters:

				Relative Prob.
Continuous range	-10.00%	to	-9.00%	1.00
Continuous range	-9.00%	to	-8.00%	1.00
Continuous range	-6.00%	to	-5.00%	1.00
Continuous range	-2.00%	to	-1.00%	2.00
Continuous range	-1.00%	to	0.00%	3.00
Continuous range	0.00%	to	1.00%	2.00
Continuous range	1.00%	to	2.00%	6.00
Continuous range	2.00%	to	3.00%	12.00
Continuous range	3.00%	to	4.00%	10.00
Continuous range	4.00%	to	5.00%	13.00
Continuous range	5.00%	to	6.00%	5.00
Continuous range	6.00%	to	7.00%	3.00
Continuous range	7.00%	to	8.00%	3.00
Continuous range	8.00%	to	9.00%	1.00
Continuous range	9.00%	to	10.00%	2.00
Continuous range	10.00%	to	11.00%	4.00
Continuous range	13.00%	to	14.00%	2.00
Continuous range	14.00%	to	15.00%	1.00
Continuous range	19.00%	to	20.00%	1.00
Total Relative Probability				73.00

Correlated with:

Auto-correlation	0.65
Money-Market Investment Return	0.41



Assumption: Small Cap Investment Return **Cell: C2-C79**

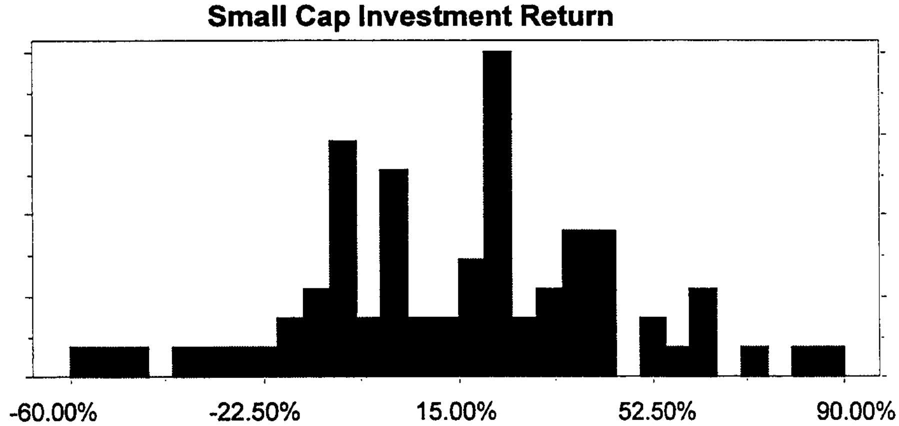
Custom distribution with parameters:

				Relative Prob.
Continuous range	-60.00%	to	-55.00%	1.01
Continuous range	-55.00%	to	-50.00%	1.01
Continuous range	-50.00%	to	-45.00%	1.01
Continuous range	-40.00%	to	-35.00%	1.01
Continuous range	-35.00%	to	-30.00%	1.01
Continuous range	-30.00%	to	-25.00%	1.01
Continuous range	-25.00%	to	-20.00%	1.01
Continuous range	-20.00%	to	-15.00%	2.03
Continuous range	-15.00%	to	-10.00%	3.04
Continuous range	-10.00%	to	-5.00%	8.11
Continuous range	-5.00%	to	0.00%	2.03
Continuous range	0.00%	to	5.00%	7.10
Continuous range	5.00%	to	10.00%	2.03
Continuous range	10.00%	to	15.00%	2.03
Continuous range	15.00%	to	20.00%	4.06
Continuous range	20.00%	to	25.00%	11.15
Continuous range	25.00%	to	30.00%	2.03
Continuous range	30.00%	to	35.00%	3.04
Continuous range	35.00%	to	40.00%	5.07
Continuous range	40.00%	to	45.00%	5.07
Continuous range	50.00%	to	55.00%	2.03
Continuous range	55.00%	to	60.00%	1.01
Continuous range	60.00%	to	65.00%	3.04
Continuous range	70.00%	to	75.00%	1.01
Continuous range	80.00%	to	85.00%	1.01
Continuous range	85.00%	to	90.00%	1.01
Total Relative Probability				73.00

Correlated with:

Large Cap Investment Return 0.79

Small Cap Investment Return



Assumption: Large Cap Investment Return **Cell: D2-D79**

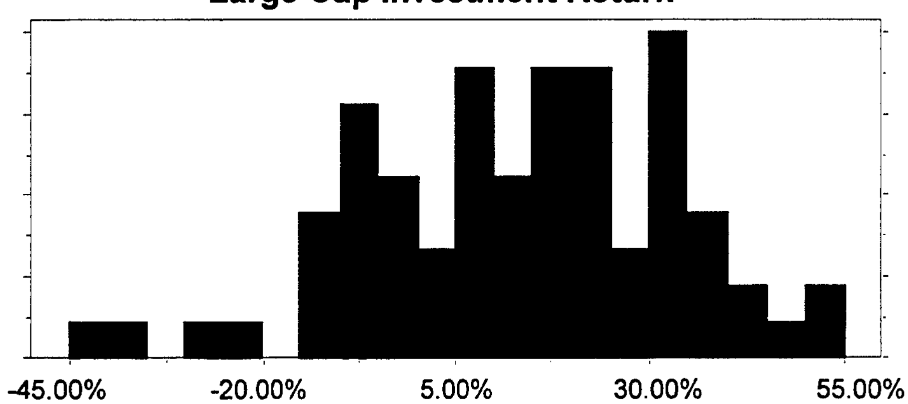
Custom distribution with parameters:

				Relative Prob.
Continuous range	-45.00%	to	-40.00%	1.00
Continuous range	-40.00%	to	-35.00%	1.00
Continuous range	-30.00%	to	-25.00%	1.00
Continuous range	-25.00%	to	-20.00%	1.00
Continuous range	-15.00%	to	-10.00%	4.00
Continuous range	-10.00%	to	-5.00%	7.00
Continuous range	-5.00%	to	0.00%	5.00
Continuous range	0.00%	to	5.00%	3.00
Continuous range	5.00%	to	10.00%	8.00
Continuous range	10.00%	to	15.00%	5.00
Continuous range	15.00%	to	20.00%	8.00
Continuous range	20.00%	to	25.00%	8.00
Continuous range	25.00%	to	30.00%	3.00
Continuous range	30.00%	to	35.00%	9.00
Continuous range	35.00%	to	40.00%	4.00
Continuous range	40.00%	to	45.00%	2.00
Continuous range	45.00%	to	50.00%	1.00
Continuous range	50.00%	to	55.00%	2.00
Total Relative Probability				73.00

Correlated with:

Small Cap Investment Return	0.79

Large Cap Investment Return



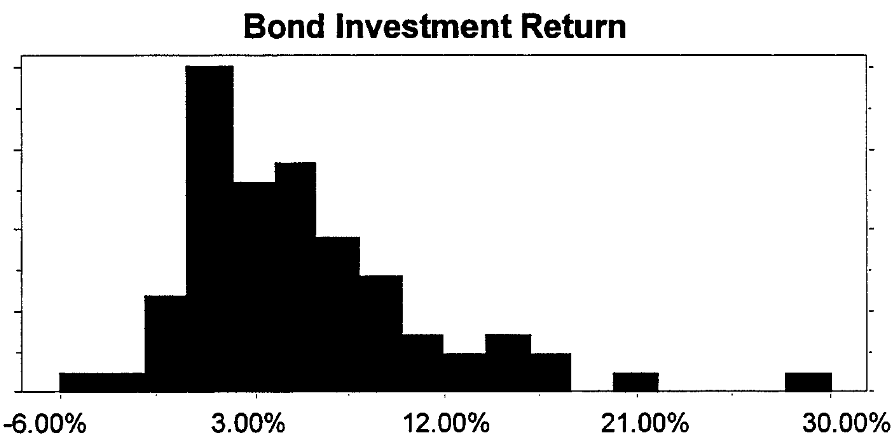
Assumption: Bond Investment Return **Cell: E2-E79**

Custom distribution with parameters:

				Relative Prob.
Continuous range	-6.00%	to	-4.00%	1.00
Continuous range	-4.00%	to	-2.00%	1.00
Continuous range	-2.00%	to	0.00%	5.00
Continuous range	0.00%	to	2.00%	17.00
Continuous range	2.00%	to	4.00%	11.00
Continuous range	4.00%	to	6.00%	12.00
Continuous range	6.00%	to	8.00%	8.00
Continuous range	8.00%	to	10.00%	6.00
Continuous range	10.00%	to	12.00%	3.00
Continuous range	12.00%	to	14.00%	2.00
Continuous range	14.00%	to	16.00%	3.00
Continuous range	16.00%	to	18.00%	2.00
Continuous range	20.00%	to	22.00%	1.00
Continuous range	28.00%	to	30.00%	1.00
Total Relative Probability				73.00

Correlated with:

Money-Market Investment Return 0.50



Assumption: Money-Market Investment Return **Cell: F2-F79**

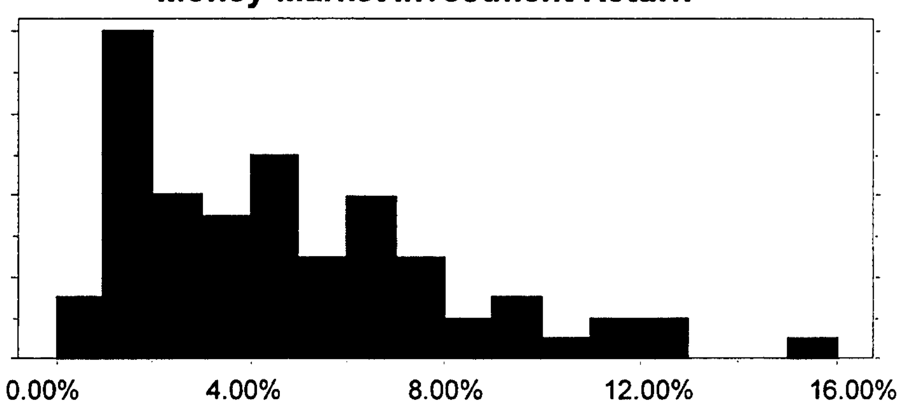
Custom distribution with parameters:

				Relative Prob.
Continuous range	0.00%	to	1.00%	3.00
Continuous range	1.00%	to	2.00%	16.00
Continuous range	2.00%	to	3.00%	8.00
Continuous range	3.00%	to	4.00%	7.00
Continuous range	4.00%	to	5.00%	10.00
Continuous range	5.00%	to	6.00%	5.00
Continuous range	6.00%	to	7.00%	8.00
Continuous range	7.00%	to	8.00%	5.00
Continuous range	8.00%	to	9.00%	2.00
Continuous range	9.00%	to	10.00%	3.00
Continuous range	10.00%	to	11.00%	1.00
Continuous range	11.00%	to	12.00%	2.00
Continuous range	12.00%	to	13.00%	2.00
Continuous range	15.00%	to	16.00%	1.00
Total Relative Probability				73.00

Correlated with:

Bond Investment Return	0.50
Inflation	0.41
Autocorrelation	0.92

Money-Market Investment Return



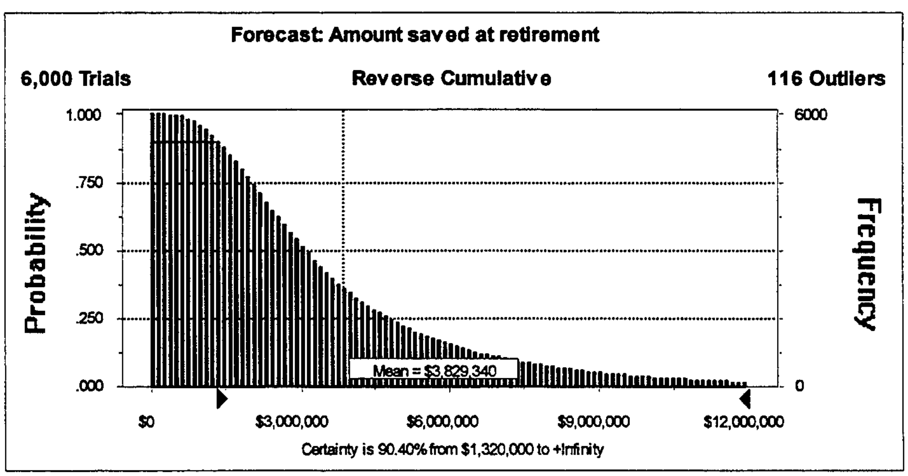
APPENDIX M. INDIVIDUAL SCENARIO SIMULATION RESULTS

Crystal Ball Report
Simulation started on 11/11/00 at 13:05:58
Simulation stopped on 11/11/00 at 13:23:52

Forecast: Amount saved at retirement Cell: C44

Summary:
Certainty Level is 90.40%
Certainty Range is from $1,320,000 to +Infinity
Display Range is from $0 to $12,000,000
Entire Range is from $295,116 to $32,938,162
After 6,000 Trials, the Std. Error of the Mean is $36,629

Statistics:	Value
Trials	6000
Mean	$3,829,340
Median	$3,071,481
Mode	---
Standard Deviation	$2,837,264
Variance	8E+12
Skewness	2.54
Kurtosis	14.42
Coeff. of Variability	0.74
Range Minimum	$295,116
Range Maximum	$32,938,162
Range Width	$32,643,046
Mean Std. Error	$36,628.91



Percentiles:

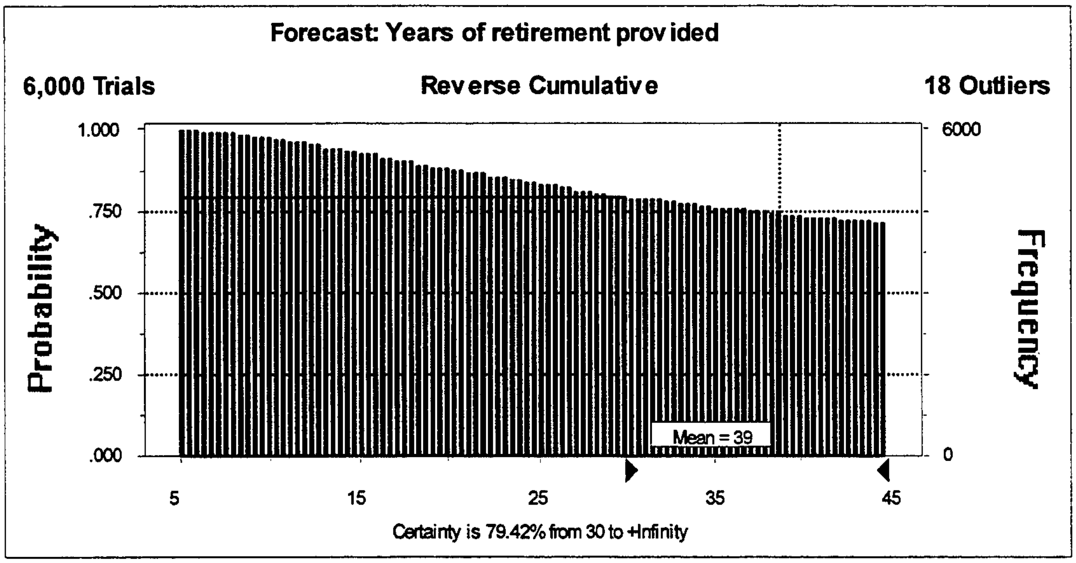
Percentile	Value
0%	$194,811
10%	$1,329,487
20%	$1,780,494
30%	$2,218,608
40%	$2,633,161
50%	$3,117,096
60%	$3,662,481
70%	$4,372,074
80%	$5,424,282
90%	$7,350,302
100%	$31,098,884

Forecast: Years of retirement provided Cell: C45

Summary:

Certainty Level is 79.42%
Certainty Range is from 30 to +Infinity
Display Range is from 5 to 45
Entire Range is from 3 to 45
After 6,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	6000
Mean	39
Median	45
Mode	45
Standard Deviation	11
Variance	127
Skewness	-1.56
Kurtosis	3.94
Coeff. of Variability	0.29
Range Minimum	3
Range Maximum	45
Range Width	42
Mean Std. Error	0.15



Percentiles:

Percentile	Value
0%	3
10%	18
20%	29
30%	45
40%	45
50%	45
60%	45
70%	45
80%	45
90%	45
100%	45

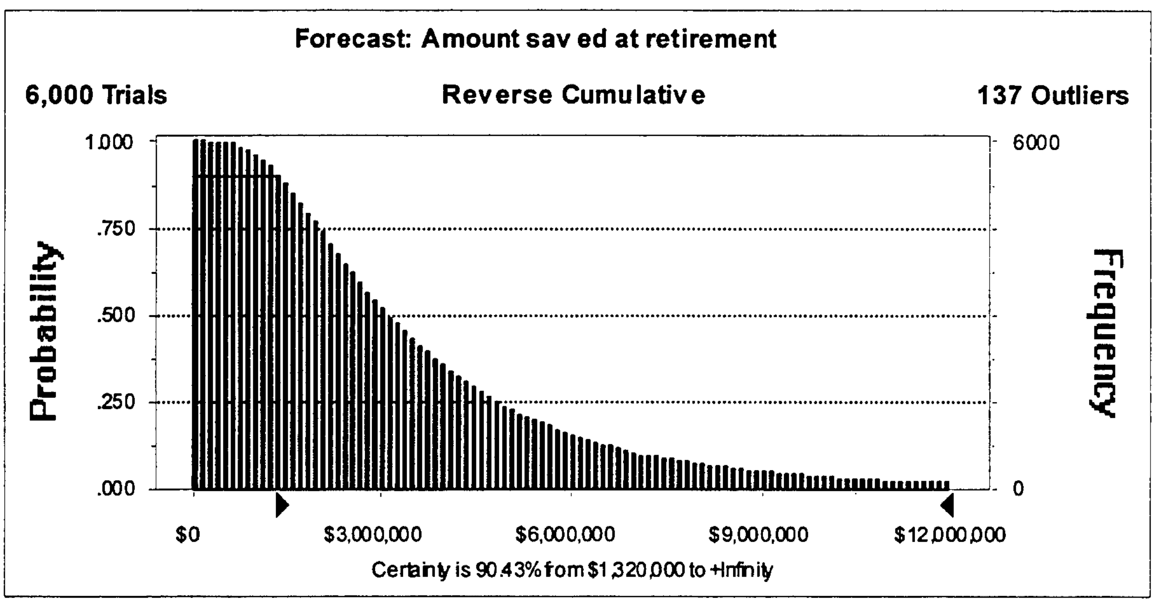
End of Forecasts

Question 1 Result
Simulation started on 11/17/00 at 14:26:48
Simulation stopped on 11/17/00 at 14:42:45

Forecast: Amount saved at retirement Cell: C44

Summary:
Certainty Level is 90.43%
Certainty Range is from $1,320,000 to +Infinity
Display Range is from $0 to $12,000,000
Entire Range is from $158,338 to $46,363,500
After 6,000 Trials, the Std. Error of the Mean is $37,199

Statistics:	Value
Trials	6000
Mean	$3,866,190
Median	$3,097,353
Mode	---
Standard Deviation	$2,881,415
Variance	8E+12
Skewness	2.79
Kurtosis	19.79
Coeff. of Variability	0.75
Range Minimum	$158,338
Range Maximum	$46,363,500
Range Width	$46,205,162
Mean Std. Error	$37,198.91



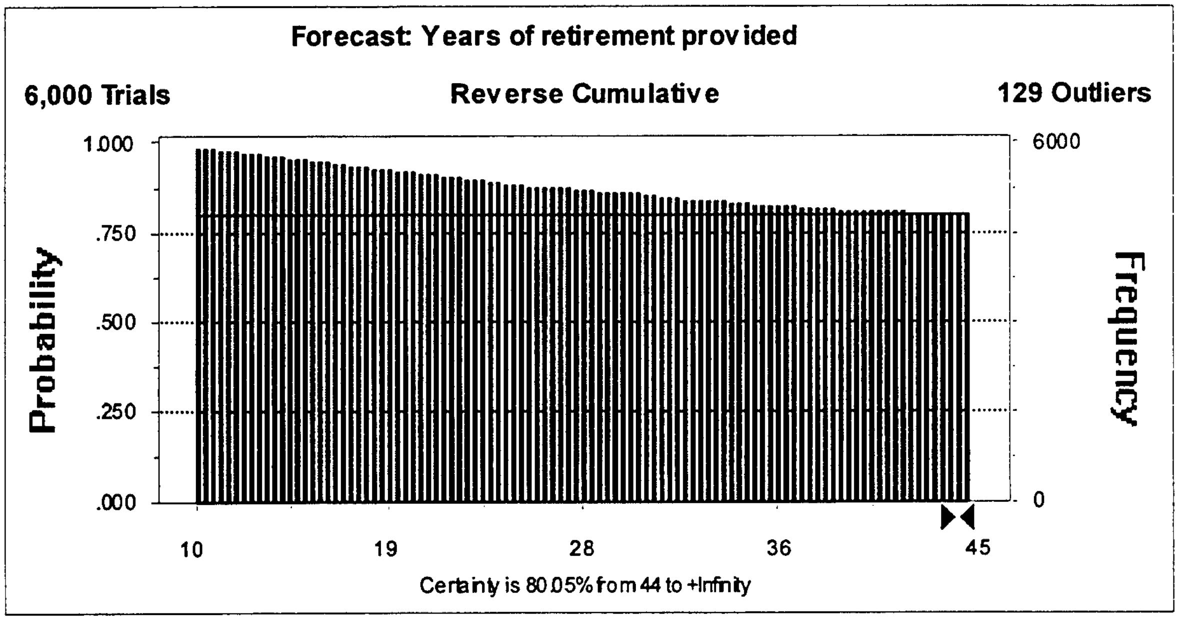
Percentiles:

Percentile	Value
0%	$281,117
10%	$1,318,898
20%	$1,779,262
30%	$2,193,207
40%	$2,624,529
50%	$3,105,674
60%	$3,738,423
70%	$4,485,245
80%	$5,577,490
90%	$7,344,166
100%	$38,786,180

Forecast: Years of retirement provided Cell: C45

Summary:
Certainty Level is 80.05%
Certainty Range is from 44 to +Infinity
Display Range is from 10 to 45
Entire Range is from 3 to 45
After 6,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	6000
Mean	40
Median	45
Mode	45
Standard Deviation	10
Variance	100
Skewness	-2.07
Kurtosis	5.88
Coeff. of Variability	0.25
Range Minimum	3
Range Maximum	45
Range Width	42
Mean Std. Error	0.13



Percentiles:

Percentile	Value
0%	2
10%	22
20%	44
30%	45
40%	45
50%	45
60%	45
70%	45
80%	45
90%	45
100%	45

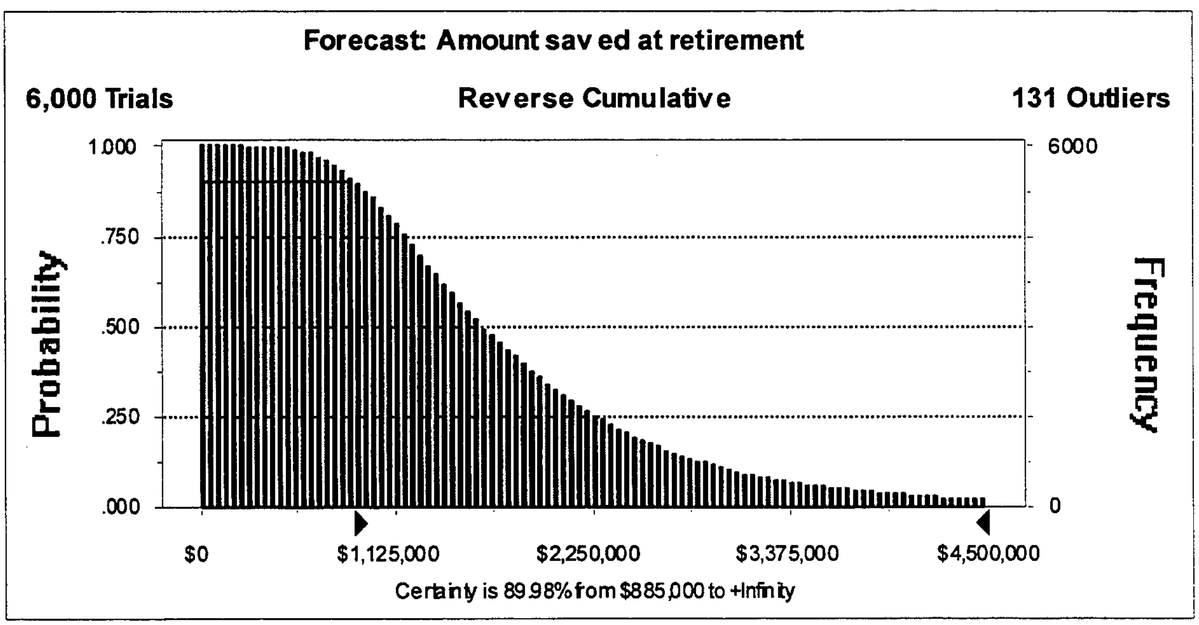
End of Forecast

Question 2 Result
Simulation started on 11/17/00 at 15:41:29
Simulation stopped on 11/17/00 at 15:57:22

Forecast: Amount saved at retirement Cell: C44

Summary:
Certainty Level is 89.98%
Certainty Range is from $885,000 to +Infinity
Display Range is from $0 to $4,500,000
Entire Range is from $247,428 to $10,984,877
After 6,000 Trials, the Std. Error of the Mean is $12,804

Statistics:	Value
Trials	6000
Mean	$1,847,937
Median	$1,613,401
Mode	---
Standard Deviation	$991,761
Variance	1E+12
Skewness	1.99
Kurtosis	10.53
Coeff. of Variability	0.54
Range Minimum	$247,428
Range Maximum	$10,984,877
Range Width	$10,737,449
Mean Std. Error	$12,803.58



Percentiles:

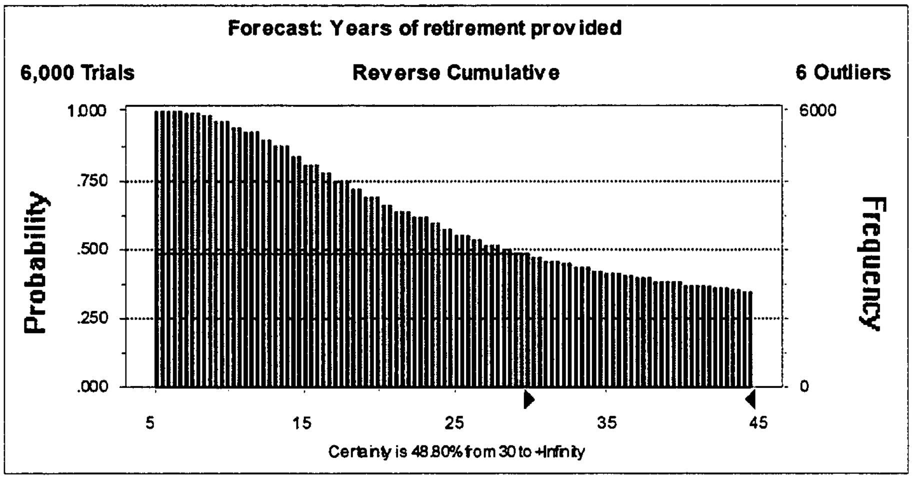
Percentile	Value
0%	$271,118
10%	$896,193
20%	$1,095,802
30%	$1,262,726
40%	$1,436,091
50%	$1,612,803
60%	$1,821,966
70%	$2,097,160
80%	$2,446,419
90%	$2,972,031
100%	$12,128,388

End of Forecast

Forecast: Years of retirement provided Cell: C45

Summary:
Certainty Level is 48.80%
Certainty Range is from 30 to +Infinity
Display Range is from 5 to 45
Entire Range is from 5 to 45
After 6,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	6000
Mean	30
Median	29
Mode	45
Standard Deviation	13
Variance	177
Skewness	-0.08
Kurtosis	1.44
Coeff. of Variability	0.45
Range Minimum	5
Range Maximum	45
Range Width	40
Mean Std. Error	0.17



Percentiles:

Percentile	Value
0%	3
10%	12
20%	16
30%	19
40%	24
50%	30
60%	39
70%	45
80%	45
90%	45
100%	45

End of Forecast

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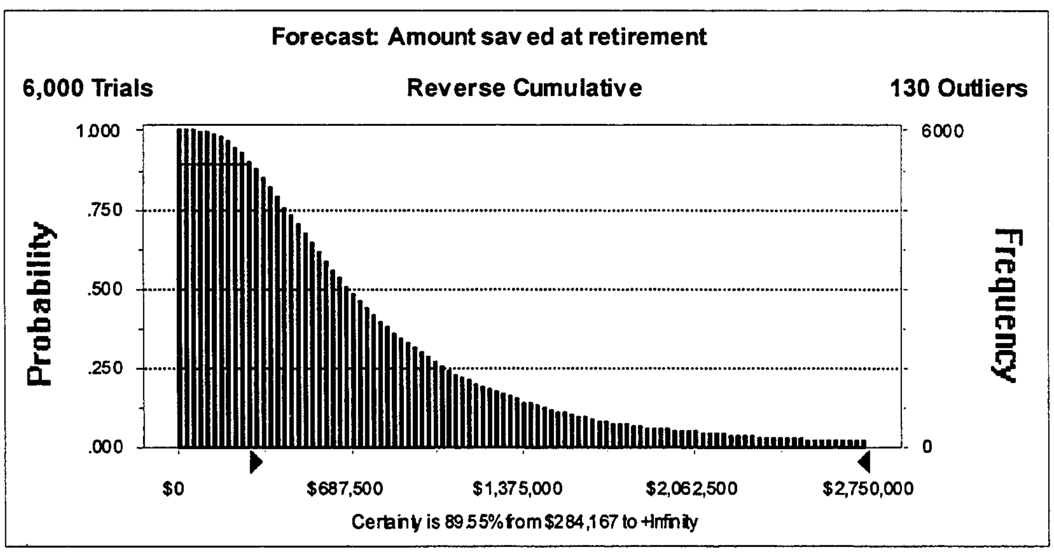
APPENDIX N. POLICY MAKER SCENARIO SIMULATION RESULTS

Results: Crystal Ball Report
Simulation started on 11/15/00 at 20:27:04
Simulation stopped on 11/15/00 at 21:45:34

Forecast: Amount saved at retirement Cell: C44

Summary:
Certainty Level is 89.55%
Certainty Range is from $284,167 to +Infinity
Display Range is from $0 to $2,750,000
Entire Range is from $67,248 to $7,878,673
After 6,000 Trials, the Std. Error of the Mean is $8,240

Statistics:	Value
Trials	6000
Mean	$846,954
Median	$671,194
Mode	---
Standard Deviation	$638,260
Variance	4E+11
Skewness	2.34
Kurtosis	12.32
Coeff. of Variability	0.75
Range Minimum	$67,248
Range Maximum	$7,878,673
Range Width	$7,811,424
Mean Std. Error	$8,239.90



Percentiles:

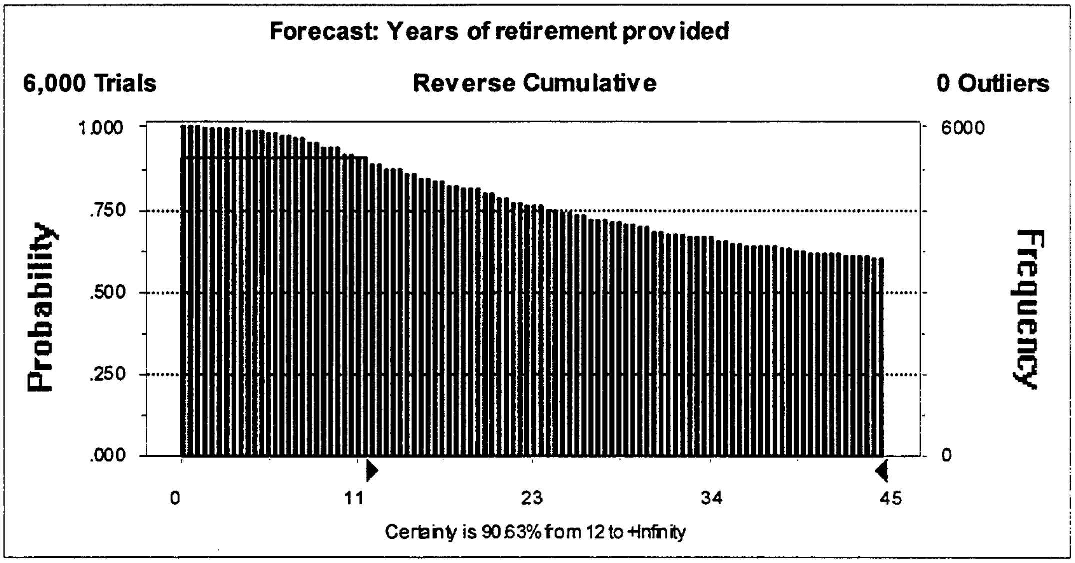
Percentile	Value
0%	$57,538
10%	$279,821
20%	$335,532
30%	$410,220
40%	$491,328
50%	$589,693
60%	$700,243
70%	$833,633
80%	$1,032,826
90%	$1,385,008
100%	$6,380,767

End of Forecast

Forecast: Years of retirement provided Cell: C45

Summary:
Certainty Level is 90.63%
Certainty Range is from 12 to +Infinity
Display Range is from 0 to 45
Entire Range is from 1 to 45
After 6,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	6000
Mean	34
Median	45
Mode	45
Standard Deviation	14
Variance	198
Skewness	-0.80
Kurtosis	2.05
Coeff. of Variability	0.41
Range Minimum	1
Range Maximum	45
Range Width	44
Mean Std. Error	0.18



Percentiles:

Percentile	Value
0%	1
10%	12
20%	18
30%	25
40%	36
50%	45
60%	45
70%	45
80%	45
90%	45
100%	45

End of Forecasts

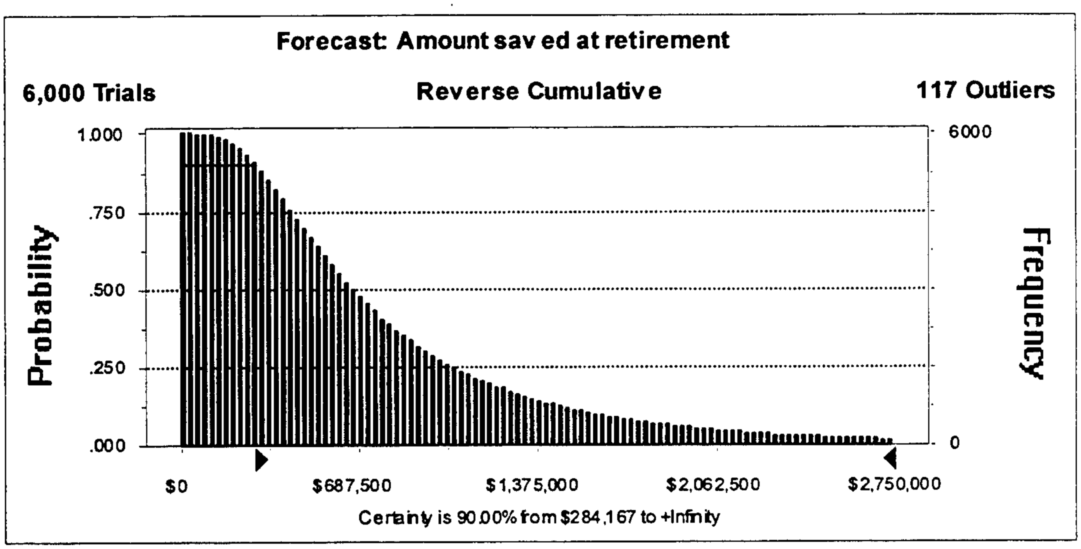
"What-if" Result

Simulation started on 11/15/00 at 18:20:45
Simulation stopped on 11/15/00 at 19:56:42

Forecast: Amount saved at retirement Cell: C44

Summary:
Certainty Level is 90.00%
Certainty Range is from $284,167 to +Infinity
Display Range is from $0 to $2,750,000
Entire Range is from $48,314 to $9,365,387
After 6,000 Trials, the Std. Error of the Mean is $8,481

Statistics:	Value
Trials	6000
Mean	$842,047
Median	$662,525
Mode	---
Standard Deviation	$656,959
Variance	4E+11
Skewness	2.87
Kurtosis	18.78
Coeff. of Variability	0.78
Range Minimum	$48,314
Range Maximum	$9,365,387
Range Width	$9,317,073
Mean Std. Error	$8,481.31



Percentiles:

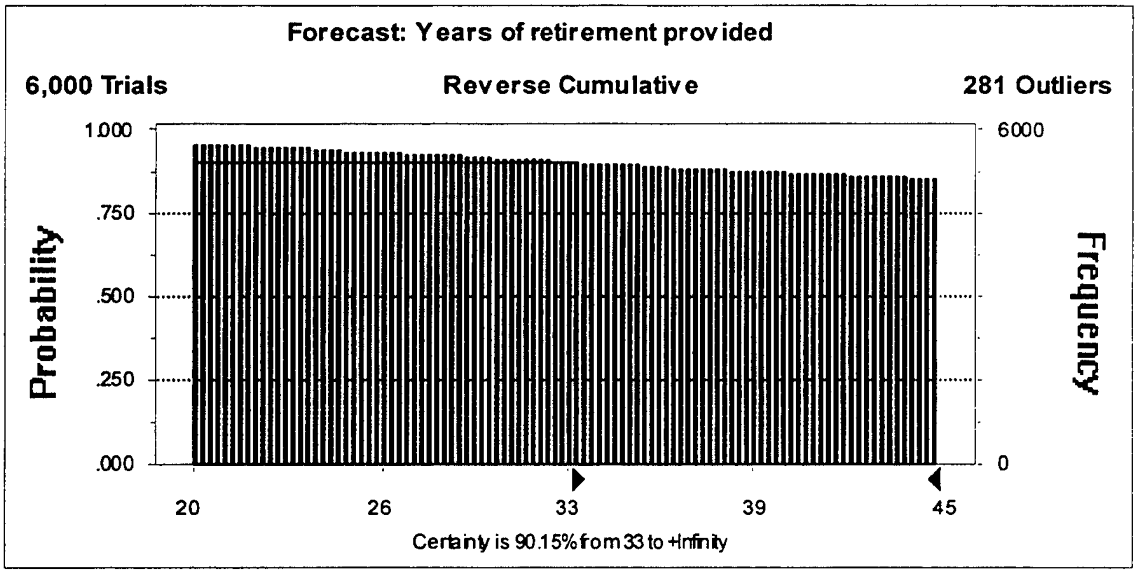
Percentile	Value
0%	$48,314
10%	$284,025
20%	$378,296
30%	$466,240
40%	$559,564
50%	$662,525
60%	$781,144
70%	$944,782
80%	$1,177,209
90%	$1,598,229
100%	$9,365,387

End of Forecast

Forecast: Years of retirement provided Cell: C45

Summary:
Certainty Level is 90.15%
Certainty Range is from 33 to +Infinity
Display Range is from 20 to 45
Entire Range is from 3 to 45
After 6,000 Trials, the Std. Error of the Mean is 0

Statistics:	Value
Trials	6000
Mean	42
Median	45
Mode	45
Standard Deviation	8
Variance	59
Skewness	-2.95
Kurtosis	10.84
Coeff. of Variability	0.18
Range Minimum	3
Range Maximum	45
Range Width	42
Mean Std. Error	0.10



Percentiles:

Percentile	Value
0%	3
10%	33
20%	45
30%	45
40%	45
50%	45
60%	45
70%	45
80%	45
90%	45
100%	45

End of Forecast

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